MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

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Annual Report

For the Fiscal Year Ending June 30, 1947

The main purpose of this report is to provide an opportunity for presenting in published form, recent results from experimentation in fields or on projects where progress has not been such as to justify the general and definite conclusions necessary to meet the requirements of bulletin or journal.

UNIVERSITY OF MASSACHUSETTS
AMHERST, MASS.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

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ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION—1946-47

DEPARTMENT OF AGRICULTURAL ECONOMICS AND FARM MANAGEMENT

A. H. Lindsey in Charge

Development of Statistical Data as Controls to Livestock Production Program. (A. A. Brown and Elaine M. Roberson.) The 6 percent areal sample proved satisfactory for estimating the total number of farms. The estimate was within one half of one percent of the map count. Errors of estimate ranged from a low of 3.97 percent for number of farms to 19.47 percent for the number of chickens on commercial poultry farms. The estimates differed substantially from census data or crop reporting service data. The usefulness of the method to Massachusetts could be improved by type-of-farm maps, improved sample design, and improvements in field procedure.

It is not the intention, however, to carry the work any further. The Crop Reporting Service has recently begun to use the areal method for selected items; and, until the results of this experience become available, this project will be held in abeyance.

The Effect of Public Regulation of Milk Marketing Upon the Organization of the Milksheds of Massachusetts Markets. (A. A. Brown.) Attention was given during the past year to the movement of supplemental milk supplies from the North Central States to eastern markets, especially Boston. Data were assembled covering routes, rates, and service.

Normally milk cars are handled as head-end tonnage on scheduled passenger trains; the rule being to put them into the first available connection. During the fall months, in recent years of heavy shipment, several of the carriers have set up a "Milk-Extra" so as to better handle the traffic.

Through rates exist between many shipping points in Illinois, Iowa, Minnesota, and Wisconsin and principal eastern markets. Commodity tariffs applicable to milk and cream moving in Passenger Train Service are effective. Most of the rates are on a ten-gallon can basis. Only a few special gallon rates are published for movement in tank cars. When milk moves in tank cars between points having only the can rate, the amount to be charged is based on the rate per gallon of the ten-gallon can rate.

Among several selected shipping points in the dairy states, there was a range of 20 cents per can in the rate on a carload minimum of 2500 gallons (250 forty-quart cans). Madison, Wisconsin, had the lowest rate to Boston of $1.39 per can, and Minneapolis the highest at $1.59 per can; both rates before tax.

This short study will become part of a more inclusive one dealing with price and volumes as well as transportation of the supplemental supplies.

A Study of Farm Real Estate Taxation, Methods of Taxation Reform, and the Effect of Such Measures on Farm Income. (A. A. Brown and Judith E. Rosenthal.) Farmers would get a greater return on their curiosity if in addition to scrutinizing their property taxes they studied their valuations. The differences among farms in land, building, livestock, and machinery valuation are substantial. These differences may be interpreted as logically reflecting the assessors' applica-

tion of the principle of "fair market value" on the grounds that no two properties are ever identical; or contrariwise, that the differences are greater than actually exist for purposes of taxation. Valuation by owners, i.e., market value, is largely influenced by subjective considerations. This element, despite supervisory safeguards, affects assessors' valuations. Subjective consideration cannot be entirely removed even if we wished to do so. Nor is its complete elimination necessary for improvements in the valuation process. This can be achieved for land by applying a system of classification based on broad capability uses. The valuation of cattle would be more equitable if it were reduced to a salvage basis. The difficulties in properly evaluating breeds and grade and mixed herds would be partially overcome if beef values were applied; these values to be determined by the Commissioner of Corporations and Taxation and announced as of November for the succeeding valuation period.

Improving Land on Massachusetts Farms. (C. R. Creek.) The benefits and economic justification of land improvement activities have been appraised on a number of farms where additional land has been brought into production. Power machines such as bulldozers and gas shovels, plus heavy equipment such as brush-breaker plows and bog harrows, have been used to improve farm lands where hand tools and the usual farm machinery were inadequate. Land improvement work in most cases has been limited to a few acres of suitable types of soil on established farms, but in some cases whole farms have been developed on abandoned land. Woodland and brush have been cleared, shrubs and weeds plowed under or harrowed, boulders and stone walls removed from fields, and lowlands drained by dynamited ditches to increase the acreage in orchards, cropland, pasture, and poultry range on farms.

Land improvement work that formerly was costly in terms of man labor now requires only a few hours with power equipment. High income in recent years from land brought into production has paid for the use of machinery in addition to the saving of labor in improvement work. Speed and timeliness were most important where land was cleared for cash crops. Pasture and range improvement aided in lower costs on dairy and poultry farms. Net profits for one or two years often met the total costs of land improvement for certain crops. In extreme cases of high costs and low returns there was no economic justification for land reclamation.

The cost of land improvement work has been amortized for a five-year and a ten-year period to show the annual carrying charge (including interest); and the yields of pasture and crops that would be necessary to pay these annual costs have been calculated on the basis of prewar prices. Normal returns over costs of production would pay the land improvement charges for tobacco in one year, and for potatoes in one to three years for different types of reclamation work. For hay, a longer period was needed to repay costs that were generally lower per acre, because value of the product was less. Generally, five to ten years were required to pay the cost of land improvement. Normal values of pasture would meet improvement costs of $75 to $100 per acre in seven to twelve years. Physical limits on the total yields of crops or pasture and the margin of return over cost of production were determining factors for the cost of land improvement which could be justified on net returns. The indirect effect on the management of the farm by increased size of business and more efficient production was also important in the final decision on this type of work.

Organization and Management of Poultry Farms. (C. R. Creek.) Summaries of poultry accounts for six years showed that the one-third most profitable farms had higher net returns than the one-third least profitable group because of these factors in the farm business: (a) Larger size of business—1200 hens per farm

contrasted with 300 hens; (b) Diversification within the poultry business—more sales of hatching eggs and chicks instead of market eggs; (c) Higher egg production—one to four dozen more eggs per hen; (d) Lower cost of feed—two to six cents less per dozen; (e) More favorable feed–egg ratio—one dozen less eggs needed to pay for 100 pounds of feed; (f) More efficient labor—85 more productive work units per man; (g) Higher price received for eggs—one to seven cents more per dozen.

The type of poultry business was an important factor in obtaining high returns as illustrated by the market egg–hatching egg combination. These flocks were of larger size in order to supply a sufficient volume of hatching eggs, egg production was high because of superior breeding and extra care, average egg prices were high because of the premium for hatching eggs, feeding efficiency was high because of high egg production, and labor efficiency was high because these farms were large one-man units and labor-saving practices and equipment were used to advantage.

Many of the family-type poultry farms were started on a part-time basis with a small flock as a minor farm enterprise or while the operator was engaged in a non-farm occupation. Eggs and poultry were sold at retail prices to overcome the disadvantages of small size, low production, high feed costs, and low labor utilization. As experience was gained, the flock was expanded and the type of business developed through the market egg to the hatching egg–market egg combination for greatest profits and most efficient operation. Another adjustment in farm organization was the short-time change to broiler production in 1942 and 1943 in combination with market egg production. Many market egg farms that were operated efficiently showed average returns over a period of years, but were likely to show low returns if one or two measures of the farm business were unfavorable in any one year.

More Efficient Labor Practices on Vegetable Farms. (C. R. Creek.) Variations in organization of the packing crew and the use of a packing table accounted for a range of four to twelve man–minutes of labor per sack to unload, grade, and pack cabbage. Use of a conveyor belt made the packing operation easier with less mechanical damage to heads but about six man–minutes of labor were required per sack.

Various methods of harvesting and packing iceberg lettuce were observed to determine a combination of practices and equipment for efficient, labor-saving, and low-cost harvesting. Preliminary results indicate that bulk hauling of field-harvested heads which are trimmed and packed from a conveyor belt in the packing shed is preferable to field packing of market crates. More specialization and skill is possible with the packing shed system and lettuce can be graded to obtain more uniform packages. Other advantages are cleanliness, less fatigue, and less wilting of heads after packing.

DEPARTMENT OF AGRONOMY

Walter S. Eisenmenger in Charge

Evaluation of Additions of Sodium Nitrate and Ammonium Sulfate when Applied to the Soil during the Late Summer Preceding the Spring when Tobacco Is Planted. (Walter S. Eisenmenger and Karol J. Kucinski.) It is known that tobacco when planted after such crops as corn, clover, or timothy will not thrive well and will show mild or malignant symptoms of brown rootrot. These plants —corn, clover, and grasses—are comparatively high in lignin at maturity. Many other plants besides tobacco do not thrive well if lignin is present in large amounts.

It is believed that the physiology of plants during the early growing period is not normal under these conditions. The postulate has often been made that micro-organisms instrumental in decomposing tissues containing much lignin need an abundance of nitrogen and consequently rob the seed plant temporarily of this element.

Nitrogen at the rate of 0, 50, 100, 200, 300, and 500 pounds per acre in the form of nitrate of soda was applied to some hay plots in the early fall and to others in the spring before the plots were plowed. Tobacco was grown on these plots. An improvement in the crop index was found in nearly all cases; but the higher rates of 300 and 500 pounds of nitrogen did not greatly increase the yield of tobacco over the lower rates of 100 or 200 pounds. A greater effect due to the nitrogen was noted on those plots that were plowed in the early fall than on those which were similarly treated but plowed in the spring. The warm early fall days apparently gave the micro-organisms an opportunity to act more fully upon the fiber plowed under in the mature grass. Where lime was applied, the response was greater than where no lime was added. It may be concluded, therefore, that the limed land served as a better medium for the decomposing micro-organisms than the unlimed land.

In a similar experiment where corn was plowed under after the ears were removed and nitrate of soda was applied, there was an increase in the yield of tobacco of 100 to 200 pounds per acre.

On plots treated similarly in every respect except that sulfate of ammonia was the form of nitrogen applied, results were not so favorable as where nitrate of soda was applied.

The Absorption of Chemical Elements by Plants. (Walter S. Eisenmenger and Karol J. Kucinski.) In the field, copper ions at the rate of 225 parts per million, calcium carbonate at the rate of 5,000 pounds per acre, and magnesium sulfate at the rate of 225 parts of magnesium per million were added to soil in which rye, barley, and buckwheat were grown. There was no pronounced lowering of the magnesium in the plants where copper was applied. However, when copper and calcium were used together, in every case there was a pronounced increase of calcium intake in all three species of plants as compared with plants which grew where calcium and magnesium were applied singly or together; where copper was applied alone; where magnesium and copper were applied together; or where there was no treatment. There would seem to be no doubt that calcium and copper together augment the intake of calcium for these three species.

Magnesium Requirements of Certain Plants. (Walter S. Eisenmenger and Karol J. Kucinski.) Magnesium deficiency is conditioned by factors other than the amount available for plants. During dry growing seasons, magnesium deficiency is not nearly so evident as during wet periods. In the experimental field, one of the deficient areas has received lime every year and the other has not received either lime or magnesium. The symptoms of magnesium deficiency are invariably more pronounced on the plot receiving no lime than on the area where lime was applied. On the magnesium-deficient areas, the pH is about 4.4 where no lime has been applied and about 6.9 where lime has been applied.

In the orchards, it has been found that applications of magnesium are often of no great aid in correcting magnesium deficiency. In the magnesium plots it has been well demonstrated by chemical analysis that very frequently no increase in magnesium or only very small increases occur in the plant tissue of perennials grown on land where magnesium has been applied. This is unlike the usual behavior of annuals.

Plants frequently found as weeds in the garden, such as grasses, members of the aster family, isolated cases of members of the Boraginaceae and Convolvu-

laceae families, and other well-developed plants, grow seemingly as well on the magnesium-deficient soil as they do on plots supplied with magnesium. On the other hand, such weeds as purslane (*Portulaca oleracea*) and the chickweeds grow abundantly where magnesium has been applied but their presence on land not receiving magnesium is negligible.

Magnesium Deficiency. (Walter S. Eisenmenger and Dale A. Hinkle.) It has been noted that chlorosis of the older leaves and lack of normal growth are symptoms of magnesium deficiency in plants. An attempt is being made to determine the relative fate of chlorophyll, carotene, and xanthophyll in the process of tissue deterioration as well as to determine the comparative supplies of magnesium in the more common agricultural soils in Massachusetts. The latter involves the base exchange capacity, the magnesium involved in the base exchange, and the total magnesium.

It has also been a part of the project to determine whether or not mass action of large quantities of magnesium when applied to apple orchards would influence magnesium intake as compared with normal applications, which in the past have proved futile. Results to date have not been encouraging. It was found that most of the apple leaves had the same magnesium content although the applications of this ion to the soil areas around different trees varied greatly in amount. This indicates that old apple trees may be adjusted physiologically to the intake of a somewhat definite amount of the magnesium ion so that mass action would be unlikely to have much effect on magnesium intake.

The relative yields of common vegetable crops are being observed to determine the economic significance of magnesium applications.

Sunflowers and Their Possibilities. (Karol J. Kucinski and Walter S. Eisenmenger.) The Canadian varieties of sunflower, which have considerably shorter stalk and smaller head than the Russian Mammoth, are being tested. This shorter variety will withstand breakage of the stalks due to windstorms, and this merits consideration. At the Experiment Station, acre yields for the Canadian type sunflower ranged from 2,000 to 2,400 pounds; the Russian sunflower averaged 2,525 pounds per acre; and a black hulled sunflower of medium height, which has been selected at the Station, produced an average of approximately 2,800 pounds per acre.

Long Time Fertility Tests. (Karol J. Kucinski and Walter S. Eisenmenger.) About sixty years ago a series of test plots was established to study the effects on the soil of a long-time fertilizer program. For the last three years, hay has been grown on these plots. As in the two previous years, yields of hay indicate that in the case of plots treated singly with either nitrogen, potash or phosphorus, the nitrogen plots showed the greatest response. Liming alone produced approximately twice as much hay as no treatment. The greatest response to lime occurred on plots treated with both potassium and phosphorus. On the unlimed plots, the heaviest yield was obtained where a complete fertilizer was used.

Soil Conservation Research Projects. (Karol J. Kucinski and Walter S. Eisenmenger.)

Use of Snow Fencing in Controlling Wind Erosion. The heavy cover of snow during the winter of 1946-47 prevented any drastic dust storms. For several years, snow fencing has been satisfactorily anchored when held with iron pipes 4½ to 5 feet long, driven 18 inches into the ground and spaced about a rod apart. It has been found that where one snow fence is placed only at the head of a "blow-out" area, perpendicular to the prevailing winds, a deposition of soil occurs when the wind blows from the opposite direction. It is suggested there-

fore, that in large "blow-out" areas, parallel fences be placed perpendicular to the prevailing wind, one at each end of the "blow-out."

Farm Fish Ponds. Considerable interest has been shown by farmers who are adopting soil conservation practices in building fish ponds on their farms. In the South and West, farm fish ponds are common and successful. In New England this is a new venture and studies are being made to determine the kinds of fish and rate and type of fertilization that should be recommended for the various types of farm ponds constructed. Very little is known about the yield and rate of growth of self-propagating fish in this vicinity. Information of this nature is greatly desired, especially in regard to species of trout.

Investigation of Beach Grass. The American or native beach grass (*Ammophila breviligulata*) found commonly on Cape Cod has been used with various degrees of success in the stabilization of beach areas and coastal sand dunes. Recently machinery has been developed for the rapid transplanting of beach grass plants, and this has made it of economic importance to obtain transplants in sufficient quantity. Studies are in progress to determine what response beach grass will make to fertilization, in the natural state and when propagated; and to find feasible methods of encouraging the growth and increasing the rate of propagation of natural stands in order that they may eventually be used commercially as transplants.

Black Root Rot of Tobacco. (C. V. Kightlinger.) The purpose of this project is to improve Havana Seed tobacco by breeding new strains that will produce tobacco leaf of better type and quality in more profitable amounts than existing strains of Havana Seed. Special emphasis is being placed on breeding new strains that are highly resistant to black root rot and capable of producing tobacco of acceptable type and quality in profitable amounts on black root-rot infested land.

Havana 211, Havana K1, Havana K2, and Havana K2-24 seem to be the best of the new strains produced so far. They yield well under most black root-rot conditions, as well as under more favorable growing conditions, and are acceptable to most growers for yielding capacity. However, owing to their larger size, these strains require greater care than many farmers are accustomed to use in preparing tobacco for harvesting and in harvesting and curing it; consequently they are sometimes not fully acceptable to the tobacco trade for quality. Better preparation for harvesting, more careful harvesting, and better curing of tobacco, regardless of whether it be the new strains or common Havana Seed, would produce tobacco of better type and quality and often of greater weight, thus resulting in more profit to both the tobacco trade and the producer, especially the latter.

Some differences exist among these new strains. Havana 211 will usually outyield the others under similar growing conditions, especially under favorable conditions. Havana K1 and K2 usually outyield Havana K2-24, especially under favorable growing conditions. Havana K2 and Havana K2-24, usually sort out in approximately the same percentage of weights per grade as does well-grown and well-cured common Havana Seed; while Havana 211 and Havana K1 usually sort out a higher percentage weight of light wrappers and seconds grades. One part of the tobacco trade seems to prefer Havana K2 and Havana K2-24 because they produce tobacco that resembles common Havana Seed so closely in type and quality. The other part of the trade seems to prefer Havana 211 and Havana K1 because they produce the greater amounts of so-called light tobacco. Further trials are needed to ascertain just how acceptable these strains may become with the tobacco trade and which of the strains may gain general preference. Better curing practices on the part of many farmers who grow these new strains may change present tendencies for preference of strains on the part of the trade.

The most desirable plants within the existing strains are being selected and propagated to improve habits of growth in general and type and quality in particular. Still other strains are being produced by crossing plants that embody the desirable properties of the different strains in highest degree.

Potato Seed Treatments. (C. V. Kightlinger and H. M. Yegian.) Seven varieties of potatoes (Green Mountain, Irish Cobbler, Russet Rural, Katahdin, Chippewa, Sebago, and Earlaine) and eight seed treatments were used to ascertain the comparative tolerance of common varieties of potatoes to the treatments and also their effectiveness in controlling rhizoctoniose and scab. The materials used were corrosive sublimate, corrosive sublimate plus acid, cold formaldehyde plus acid, Semesan Bel, Sanoseed, Spergon, Fermate, and Thiosan, all prepared and used according to recommendations. The potatoes were dormant or only slightly sprouted at the time of treatment.

The inorganic materials caused little if any noticeable injury to tubers or reduction in stands of Green Mountain, Irish Cobbler, and Russet Rural; slight injury to tubers and moderate reduction in stands of Katahdin, Sebago, and Earlaine; moderate injury to tubers and heavy reduction in stand of Chippewa. The organic materials caused no noticeable injury to tubers of any variety and no reduction in stands of Green Mountain, Irish Cobbler, and Russet Rural; little reduction in stands of Katahdin, Sebago, and Earlaine; and moderate reduction in stand of Chippewa. Injury to tubers consisted not only of injury to eyes and sprouts but also of pitting of the tubers. The treated and untreated potatoes of each variety were taken from the same lot; therefore, it seems reasonable to conclude that the reductions in stand were caused by the treatments and not by rhizoctoniose on the sprouts before they emerged from the ground.

None of the seed treatments seemed to increase the vigor of the plants. On the contrary, there seemed to be some retardation in the emergence of plants from the treated seed of some of the varieties. There were no consistent differences in the amounts of infection of rhizoctoniose, either on the growing plants when about a foot tall or on the tubers grown from treated and untreated seed. Although these experiments yielded no specific information on the effectiveness of disinfecting treatments to prevent injury by Rhizoctonia to the young sprouts before they emerge from the ground; nevertheless, on the basis of the results obtained, it seems reasonable to conclude that the use of disinfecting seed treatments is of doubtful value in preventing the development of rhizoctoniose on the stems and tubers of potatoes.

Little or no scab developed on any of the potatoes at any time in these experiments, so they yielded no information regarding the effectiveness of these disinfecting seed treatments for controlling scab. However, owing to the widespread occurrence of the scab-causing organism (like the rhizoctoniose-causing organism) in most cultivated land, and the fact that the scab disease develops late in the growth of potatoes, the use of disinfecting seed treatments would seem to be of doubtful value for controlling scab. Satisfactory control of both rhizoctoniose and scab of potatoes must be sought by other means than the use of disinfecting seed treatments.

Fertilizer Placement for Potatoes. (C. V. Kightlinger and H. M. Yegian.) Green Mountain potatoes were grown on one-twentieth acre plots, replicated four times. Approximately one ton per acre of 5-8-7 fertilizer was applied in four different ways: all banded, two-thirds banded and one-third broadcast, one-third banded and two-thirds broadcast, and all broadcast. The broadcast fertilizer was applied and harrowed into the soil before the potatoes were planted. The potatoes were planted on May 20; sprayed with Bordeaux mixture at weekly

intervals throughout the season, beginning June 26, and with DDT and nicotine sulfate as needed; and harvested October 19 and 21.

There was no striking difference in the yields of potatoes of any class or size obtained from the different ways of using fertilizer this season.

Potato Variety Trials. (Karol J. Kucinski, Ralph W. Donaldson, Walter S. Eisenmenger.) The 1946 season was considered an exceptionally good potato year. The yields obtained in the variety tests ranged from 474 bushels per acre for Sequoia to 190 bushels per acre for USDA 46952. Based on yields of marketable size, the potato varieties in the Experiment Station plots ranked as follows: Sequoia, Green Mountain, Pontiac, Mohawk, Chippewa, Teton, Houma, Sebago, Irish Cobbler, Warba, USDA 627-103, Katahdin, and USDA 46952. The Houma variety produced 347 bushels per acre, but approximately 23 percent of these were "B" size or smaller.

Pasture Renovation Experiments. (Wm. G. Colby.) Work with pasture renovation was begun in 1943 in cooperation with the U. S. Department of Agriculture Regional Pasture Laboratory at State College, Pennsylvania. The nature and scope of the project was given in last year's report (Mass. Agr. Exp. Sta. Bul. 436: 13-14, 1946.)

Herbage Yields. Yield data from all of the different trials thus far conducted, indicate that untreated sods yielded from practically nothing for very poor sods up to one ton of dry matter per acre for the better ones. Good Kentucky bluegrass and natural white clover sods liberally topdressed with lime and a complete fertilizer produced up to two tons of dry matter per acre, while areas which had been tilled and re-seeded in addition to being limed and fertilized, yielded three tons of dry matter and in several cases three and one-half tons. The reseeded areas, in addition to giving greater total yields, maintained more uniform production throughout the grazing season. A mixture of Ladino clover, red clover, and alsike was used on all areas. Smooth brome grass (*Bromus inermis*) was the grass most frequently used, with smaller plots of orchard grass (Finnish late hay strain), timothy, and meadow fescue also included for comparative purposes. Although it is sometimes difficult to secure good stands of brome grass, this grass seems to show the most promise.

Land Drainage. Some of the best potential pasture land in the State is now practically useless because of poor drainage. Therefore, the first step in any renovation program is to provide adequate drainage. Many such areas can be satisfactorily and economically drained by dynamiting; others may require the use of a dry land dredge of some sort.

Reclaiming Newly Drained Land. The surface of newly drained land is usually so rough and uneven that considerable difficulty may be experienced in seedbed preparation even with the aid of a heavy brush and bog harrow. Observations were made on the use of a large machine using the "roto-tiller" principle for tilling rough, recently drained areas. In one operation this machine not only leveled off but broke up and cut to pieces the many tough fibrous tussocks or hummocks which were present. Where the land is not stony this machine shows real promise.

Time of Seeding. Comment was made last year that late summer seeding had been more satisfactory than spring seedings. It was pointed out that weather conditions were usually more favorable for summer than for spring seedings and that this was probably the most satisfactory explanation. It now appears that weather is not the only factor involved. In several instances where the land had been long out of cultivation, difficulty was experienced in establishing a new

seeding when the seeding operation followed immediately after tilling, liming, and fertilizing. If seeding was delayed for several weeks, little difficulty was experienced. Apparently, therefore, the late summer seedings were more successful, not only because weather conditions were more favorable, but also because a period of time had elapsed between tilling, liming and fertilizing, and seeding. In bringing under cultivation land which has long been idle, farmers are advised to apply lime and fertilizing materials some weeks ahead of seeding or planting.

Red Clover Variety Trials. (Wm. G. Colby.) This project, carried on in cooperation with the U. S. Department of Agriculture Bureau of Plant Industry, is concerned with the resistance of some of the newer strains of red clover to certain diseases. Northern anthracnose (caused by *Kabatiella caulivora*), a disease which is becoming increasingly serious in other sections of the country, was prevalent on some of the more susceptible varieties included in this year's test. The variety Midland, for example, was seriously damaged. It remains to be seen whether or not this disease will become a serious hazard to red clover in Massachusetts. It may be that weather conditions this year were peculiarly favorable for its development.

Trials with Sorghum and Sudan Grass Strains. (Wm. G. Colby.) Notwithstanding the superior performance of a well-established, well-managed Ladino clover–brome grass pasture during July and August, the need for additional grazing is frequently felt, particularly during dry, hot seasons. One of the best crops available for providing supplementary grazing at this time is sudan grass or possibly sweet sorghum. Both produce heavy crops of palatable nutritious feed. If a reasonable amount of care is exercised in seedbed preparation, fertilizing, and seeding, crop failures are rare. Thus far, however, dairymen have been cautious about growing either of these species largely because of the possible danger of hydrocyanic acid poisoning.

Last season several strains of sudan grass and one of sweet sorghum were grown. In addition to obtaining yield data, tests were made of the cyanide content of the herbage at two growth stages. The Rancher strain of sweet sorghum was obtained from South Dakota where it was bred for low hydrocyanic acid content.

Samples were first taken for hydrocyanic acid determination on July 22 when most strains were in full head. All plots were then cut, the hay removed and an application of ammonium nitrate made to supply elemental nitrogen at the rate of 65 pounds to the acre.

Samples for a second test were taken on September 12. All chemical determinations were made by Professor Emmett Bennett of the Department of Chemistry.

Although Rancher Sorghum and Tift sudan grass ran considerably higher in hydrocyanic acid content at the first cutting than commercial sudan or sweet sudan, a cow would have had to consume from 50 to 60 pounds of green material at one time of either of these strains before there would have been any danger of poisoning. She would have had to consume 300 pounds of sweet sudan grass before being poisoned.

All strains ran much higher in hydrocyanic acid at the second cutting, with only small differences between strains. A cow would have had to consume from 20 to 25 pounds of green material of the second cutting at one time before danger of poisoning. Heavy fertilization with a nitrogen fertilizer was no doubt an important factor in the production of the relatively high content of hydrocyanic acid of the second cutting.

It would appear from these results that all of the four strains tested could be grown for midsummer pasture in Massachusetts without serious hazard of causing hydrocyanic poisoning.

Corn Improvement Program. (Hrant M. Yegian.)

Uniform Double Cross Tests. Twenty-five commercial hybrids of the U. S.-13 maturity group were tested, with five northeastern experiment stations cooperating. An experimental hybrid, (B164 x WF9) x (40B x L317), gave the highest yield—134.3 bushels of shelled corn per acre, calculated at 15.5 percent moisture, and 21.1 tons of silage per acre, calculated at 70 percent moisture. Ohio 3143, Pioneer 300, Funk G-94, Iowa 4059, and Conn. 830 were also high producers. The hybrids which performed well at this station were also consistently high in yield in the other four tests.

None of the predicted double crosses in the early maturity group produced as much grain as the Mass. 62. New experimental double crosses are being tested this year in an effort to find one which will outyield Mass. 62.

Single Cross Test. A set of 45 single crosses involving all possible combinations of ten selected inbred lines in the early maturity group and another set of 45 single crosses in the midseason maturity group were tested cooperatively. On the basis of these tests a few of the promising predicted double crosses are being made for testing during the 1948 season.

Last year a new set of 45 early maturing single crosses was made here. They are being tested for their general adaptability in the Northeastern region.

Date and Rate of Planting. The results of further yield tests with four hybrids ranging in maturity from early to late, planted on three different dates (May 10, 20, and 30) and at three rates (3, 4, and 5 plants per hill), were again not very reliable. Excessive rainfall in the spring and poor drainage of the field caused wide discrepancies among the replicates. Although early planting hastened maturity from 7 to 10 days, in was very difficult to prepare a deep mellow seedbed, control the weeds, and secure a good stand, because of cold and wet soil conditions which favored poor germination and seed rot.

Onion Breeding. (Hrant M. Yegian.) *Hybrid Onions.* In 1946 a number of bulbs of male-sterile lines supplied by Dr. H. A. Jones of the U. S. Department of Agriculture were pollinated with selected strains of our Ebenezer lines to determine their relative combining ability. The resulting hybrid seeds from these crosses are being used for set production and will be distributed to interested local farmers for experimental testing.

Pre-harvest Spraying. Further tests for the control of storage rot of onions by spraying with Fermate, Puratized N5E, Isothan Q-15, Wettable No. 604, Wettable Spergon, and Dithane D-14 did not give any control of rot in storage. The various fungicidal chemicals were applied three times at weekly intervals before the onions were pulled.

In most instances infection of the bulbs takes place through wounds at the neck of the topped onions or through damaged roots, which may account for the ineffectiveness of the fungicides to control storage rot. Immature onions, big fleshy bulbs, or thicknecked bulbs are especially susceptible to infections. The most practical method known for reducing loss is to store only sound, properly cured onions in cold storage under controlled conditions at 32°–35° F. and low humidity.

Fertilizer Application. It is a generally accepted practice in the Valley to apply from 2000 to 2500 pounds per acre of a complete commercial fertilizer such as 5-8-7 to onion fields. Although the fertilizer is broadcast and disked in to a depth of 3 to 4 inches about a week prior to planting the sets, there have been cases, nevertheless, where serious fertilizer injuries have occurred on light sandy soils

under adverse weather conditions. Furthermore, most of the growers have found it necessary to make an additional application of 500 to 700 pounds of a complete fertilizer during late May to replace excessive leaching losses by spring rains and to supply readily available plant food to the crop during a time when it is making a steady and rapid growth.

The results of last year's trial indicate that more efficient use of commercial fertilizer could be made by split application, consisting of 1000 pounds per acre of 5-8-7, broadcast and disked in prior to planting; 500 to 700 pounds per acre about the middle of May; and 500 pounds more about the first part of June. This would insure a steady supply of abundant plant food with a minimum loss through leaching and should entail no extra labor inasmuch as there are available fertilizer distributers which can be attached to powered onion cultivators.

DEPARTMENT OF ANIMAL HUSBANDRY

Victor A. Rice in Charge

A Study of the Mineral Elements of Cows' Milk. (J. G. Archibald.) The work with cobalt has been completed, at least insofar as the present development of the project is concerned; and the results have been published in the *Journal of Dairy Science* Vol. 30, No. 5, May 1947. The following is quoted from the article:

> Cobaltous acetate was fed as a supplement (500 mg. daily) to the rations of eight cows for a period of two months by the double reversal method and the milk was analyzed for cobalt. The results revealed that feeding the supplement consistently raised the amount of cobalt in the milk. The average increase was four-fold. The milk from cows receiving the supplement averaged 2.4 micrograms of cobalt per liter in contrast with 0.6 micrograms per liter when the cows were on the control ration.
>
> The obvious possible significance of these results lies in their application to calf nutrition. In our experience, young stock have showed greater susceptibility to the nutritional anemia which is characteristic of cobalt deficiency than older cattle have. In the light of these results, it would seem that in areas where cobalt deficiency is common, the requirements of calves for this element might most naturally and logically be supplied through the milk of cows whose rations have been fortified with supplemental cobalt.

Interest in this work has been shown recently on the part of the indusrial processors of milk. One firm states that in connection with their "use of milk products as fermentation media, . . . very small concentrations of the so-called trace elements are of great importance." Cobalt is stressed by them as one of the principal elements in this connection.

The element nickel will be investigated during the winter of 1947-48.

A Study of Quality in Roughage: Composition, Palatability, and Nutritive Value of Hays as Affected by Curing, Harvesting, and Storing Procedures. (J. G. Archibald, M. L. Blaisdell, and H. N. Stapleton.) Preliminary studies with the 1945 and 1946 hay crop indicate marked differences in the composition of different lots of hay, especially with respect to their content of protein, sugar, and carotene. These differences are thought to be due to such variables as weather during the growing period and at curing time, kind of crop, and methods of harvesting and storing. Their significance with regard to palatability and nutritive value of the hay produced is, in our present state of knowledge, pretty largely a matter of conjecture. Existing knowledge on the subject is fragmentary, inconclusive, and even contradictory. It is the aim of this project to obtain authentic information. Work has just been begun and results are not as yet available.

DEPARTMENT OF BACTERIOLOGY

Leon A. Bradley in Charge

Septic Tank Studies. (James E. Fuller.) This is a continuation of work previously reported (Mass. Expt. Sta. Bul. 436, p. 17, 1946). This study was concerned with the penetration of sewage-type coliform bacteria into the soil of disposal fields receiving sewage effluents from three septic tanks which represented three retention periods for raw sewage: 8, 12, and 24 hours. The soil samples were examined to determine their coliform indices by the conventional procedure of gas production in lactose broth, as outlined in the Standard Methods of Water Analysis (American Public Health Assn.). Organisms isolated from positive fermentation tests were studied to determine their relationship to sewage-type coliform bacteria (*Escherichia coli*). Results showed almost no sewage-type organisms in the soil, in spite of the fact that the flow from the 8-hour retention tank was so rapid that soil surrounding the disposal line was frequently saturated with moisture. Organisms isolated were, for the most part, the same as those isolated from soil (of the same type) that did not receive septic-tank effluent. Two conclusions resulted from the study: (1) the length of retention of sewage in the tanks did not influence the results obtained from the soil, and (2) the sewage-type coliform bacteria isolated from the raw effluent either did not penetrate into the soil or did not survive. Further study is planned to investigate the survival of sewage-type coliform bacteria in soil under different conditions.

Bactericidal Properties of Surface-active Agents. (James E. Fuller.) It was reported previously (Mass. Expt. Sta. Bul. 436, p. 17, 1946) that preliminary tests had been made on 42 surface-active agents to determine their germicidal efficiency. Several of these agents, representing three chemical groups, were chosen for further study of their germicidal properties, in different concentrations, against two representative types of bacteria, *Escherichia coli* and *Staphylococcus aureus*. The chemical groups represented were quaternary ammonium compounds, phosphonium compounds, and aliphatic sulphonates. Usually a certain concentration is recommended for the use of an agent. Results of the experiments indicated that the effectiveness of the agents varied for the different bacterial species, and that a formula could be derived for each agent showing the relationship of concentration of the agent and dosage time for any given bacterial species. The results of the experiments indicated that the agents could be made more widely useful if directions for their application were made more flexible, and economy of materials might result if weaker concentrations were employed where speed of disinfecting action is not important or necessary.

Microbiological Fixation of Copper in Soil. (Charles Hurwitz.) This study was undertaken to determine the effect of the soil microorganisms on the availability of the soil supply of copper to higher plants. Copper leached from the soil by neutral, normal ammonium acetate is considered available. Leachable copper was found to be greatly increased by an unknown soluble component of oat straw and alfalfa meal when either sodium chloride or ammonium acetate was used as the leaching solution, the effect being found in both Merrimac sandy loam and Dunkirk silty clay loam. This unknown soluble component is decomposed by soil microorganisms in about 14 days at 29° C., 37° C., and 45° C., no marked differences being observed at any of these temperatures. At 2° C., no decomposition of the soluble component occurred in 21 days, but when this soil was placed at 29° C., decomposition proceeded as before. Work is in progress now to characterize this unknown soluble component and to determine its agricultural significance.

Laboratory Service, July 1, 1946 to October, 1946. (James E. Fuller.)

Water samples, bacteriological tests..... 22

This service was discontinued in October, 1946.

DEPARTMENT OF BOTANY

A. Vincent Osmun in Charge

Diseases of Trees in Massachusetts. (M. A. McKenzie and A. Vincent Osmun.)

The Dutch Elm Disease Problem. In 1941 the Dutch elm disease, caused by the fungus *Ceratostomella ulmi* (Schwarz) Buisman, was discovered in Massachusetts. One diseased tree was found in Alford, Berkshire County, just over the line from New York State. As of July 8, 1947, the disease has been isolated from 502 trees of 52 municipalities in 8 counties of Massachusetts. The spread of the disease from year to year is shown by the following table:

Year	Cumulative Totals		
	Trees	Towns	Counties
1941	1	1	1
1942	7	5	2
1943	11	6	2
1944	43	15	2
1945	85	24	3
1946	381	47	8
1947 (July 8)	502	52	8

Until 1946, occurrence of the disease in Massachusetts was limited to the Connecticut Valley and the area between this boundary and the New York State line. Currently, however, affected trees were discovered in Quincy and more recently in nearby towns in Norfolk County as well as in Plymouth and Bristol Counties. Since the principal known vector of the causal fungus is a bark beetle, *Scolytus multistriatus*, which has been known to be present in eastern Massachusetts from about 1900, the diseased trees in that section of the State may be regarded as more than individual isolated cases such as sometimes occur independently of the major area of disease and beetle vector infestation. On the basis of experience, increase in the number of diseased trees locally parallels closely the build-up of beetle population if the causal fungus is present.

An important part of the work is now, and must continue to be, the exploration of possible further spread of the disease in Massachusetts, as well as obtaining additional data in areas where trees are known to be affected. Detailed reports are furnished to the Massachusetts Department of Agriculture, to local officials, and to private citizens involved, regarding findings in individual municipalities, with special reference to need for action in retarding the spread of the disease.

Experiments are in progress in cooperation with the Department of Entomology on the use of spray materials for the control of carrier beetles.

The investigation of disease resistance deserves further attention. Thus far, however, other commitments have precluded studies to determine evidence of possible resistance to disease in elms of Massachusetts.

Other Tree Problems. Fifty-three diseases of twenty-nine species of trees, including eight diseases of elm, were identified from approximately 450 specimens and inquiries received during the year. The *Cephalosporium* wilt of elm was

reported from two additional municipalities in the State. *Verticillium* sp. was isolated from several species of woody plants.

Anthracnose of maples and oaks, black spot of elms, and other leaf diseases caused by fungi are prevalent on trees currently. In some instances premature defoliation is traceable to this type of fungus infection.

A needle blight of Colorado fir (*Abies concolor*) was found on specimens collected at Newburyport, Mass. This disease is caused by the fungus *Rehmiellopsis balsameae*. Under suitable conditions the resultant disease may become epiphytotic in plantations. Accordingly, the growth of the current season may be rather uniformly scorched in appearance, resembling damage by late frosts to which cause this fungus disease was formerly often attributed. Although the disease was first known in Massachusetts on Colorado fir, later the causal fungus was found on balsam fir (*Abies balsamea*) in Maine. It seems assured that the fungus is native in eastern United States on balsam fir and may have spread to ornamental plantings of Colorado fir introduced into the vicinity. The disease has not been found in the Western States, native range of the Colorado fir.

Neglect of general maintenance work on street trees is increasingly important as a cause of tree injury. The rising cost of this work to municipalities is the primary factor involved. The result of the accumulation of weakened parts of trees may be seen widely in the State following ordinary storms. Inevitable accidents involving such trees may serve to direct needed action toward necessary, constructive tree improvement and protection programs.

Damping-off and Growth of Seedlings and Cuttings of Woody Plants as Affected by Soil Treatments and Modifications of Environment. (W. L. Doran.) Work on the vegetative propagation of the Kudzu vine was continued and a paper on the subject prepared for publication. Best results with this species were obtained when cuttings, each made to consist of one node, its leaf and a young axillary branch, were taken in mid-July, given a powder-dip treatment with indolebutyric acid, and set in sand–peat. The rooted cuttings were wintered in the greenhouse and, in cooperation with the Department of Agronomy, set in the field in spring for later observations as to hardiness and growth.

Work on the vegetative propagation of hemlock and of white pine was continued and a bulletin written and published about the latter.[1]

Different clones of hemlock, like different clones of white pine, were found to respond very differently to treatments with the same root-inducing substance, the best rooting being from more than 80 percent with some clones to less than 10 percent with other clones. Indolebutyric acid 150 to 200 mg./l., 20 to 18 hr., often improved the rooting of cuttings of hemlock taken in early winter; but the rooting of cuttings taken in October was more improved by naphthaleneacetic acid 50 mg./l., 18 hr.

Continued attention was given to the use of fungicides in combination with root-inducing substances for the treatment of cuttings, and it was found that a given fungicide when added to Hormodin No. 3, in the proportion of 15 percent fungicide, does not have the same effect on cuttings of all species. Fungicides which improved the rooting of summer cuttings when thus used were zinc ethylene bisdithiocarbamate (HE178E), ferric dimethyldithiocarbamate (Fermate), and zinc mercaptobenzothiazole with (leaf-bud) cuttings of a *Rhododendron catawbiense* hybrid; diphenyl guanidine phthalate (Gauntal) with cuttings of *Viburnum Carlesii*; Fermate with flame azalea; 2, 3-dichlor-1, 4-naphthoquinone (Phygon) with *Cotoneaster adpressa*, and HE178E with red cedar. Phygon was also safe with *Viburnum Burkwoodii*.

[1]Doran, W. L. Vegetative propagation of white pine. Mass. Agr. Expt. Sta. Bul. 435, 16 pp. illus. July 1946.

Tetramethyl thiuram disulfide (Tuads), zinc trichlorophenate (Dow Seed Protectant No. 9) and Guantal were apparently injurious to the leaf-bud cuttings of Rhododendron, and Dow Seed Protectant No. 9 had a similar unfavorable effect on cuttings of red cedar and Japan quince.

The effects of solution-immersion treatment applied in the usual manner with only the bases of the cuttings being immersed, were compared with the effects of immersion of the entire cuttings in solutions of a root-inducing substance. Rooting of fall cuttings of two yews was more hastened or improved by complete immersion in indolebutyric acid 150 mg./l. or naphthaleneacetic acid 25 mg./l., 18 hr. than by basal treatment only and this was true also of fall cuttings of Hinoki cypress in indolebutyric acid 50 mg./l., 18 hr. But the rooting of fall cuttings of arbor-vitae and two species of Juniper was as much improved by one method as by the other, and the rooting of cuttings of five hemlocks taken between October and January was more improved by immersing only the bases of the cuttings than by immersing the cuttings entirely.

Some work was done with potassium nitrate in solution, used with or without a root-inducing substance. Rooting of December cuttings of Norway spruce was improved by potassium nitrate 100 mg./l., 23 hr., used alone. Rooting of fall cuttings of red cedar, oriental bitter-sweet, and inkberry was more improved by potassium nitrate 50 mg./l. used with indolebutyric acid than by the latter used alone.

Powder-dip treatment of December cuttings of Norway spruce with 2, 4, 5-trichlorophenoxyacetic acid 0.5 mg./gm. resulted in improved rooting if the carrier was activated charcoal but not if it was talc.

Arasan (tetramethyl thiuram disulfide), used as a seed treatment, protected seedlings of *Pinus Mugo* var. *Mughus* against damping-off better than did either Phygon or Spergon (tetrachloro-parabenzoquinone) similarly used.

Applied as a soil treatment immediately before seeding, Arasan 0.5 gm. per square foot improved the stands of Carolina Rhododendron and a *Rhododendron catawbiense* hybrid.

Diseases of Plants Caused by Soil-infesting Organisms, with Particular Attention to Control Measures. (W. L. Doran.) The application of soil fungicides in fertilizer used as a carrier was found to be a simple and effective method for the control of certain soil-borne fungus diseases of plants. It is especially useful in the case of such light applications (per acre) that the fungicide could hardly be distributed except in some carrier. A liquid carrier would mean more labor and, as is stated below, the results with water may be inferior to those with fertilizer.

Especial attention was given to the control of clubroot of cabbage, smut of onion, and damping-off of certain vegetables by some organic fungicides applied to the soil in a 5-8-7 fertilizer (15.6 gm. per square foot) immediately before seeding. The effectiveness and safety of some of the fungicides thus applied were compared with their effectiveness and safety when applied in water to soil immediately after seeding. Observations were meanwhile made as to which soil fungicide applied in fertilizer is better and safer with one species of plant, which with another.

Dithane D14 (disodium ethylene bisdithiocarbamate), Dow Seed Protectant No. 9 (zinc salt of 2, 4-trichlorophenol), Fermate (ferric dimethyldithiocarbamate), Arasan or Tuads (tetramethyl thiuram disulfide) gave better and safer control of damping-off of all vegetables when applied in fertilizer to soil before seeding rather than in water after seeding.

Phygon (2, 3-dichloro-1, 4 naphthoquinone), Tuads, and Dithane applied in fertilizer gave better control of damping-off in limed soils than in the same soils not limed. But there were also good results with these and other fungicides applied in fertilizer to unlimed soils.

The fungicide, in fertilizer, which gave the best results with one kind of vegetable did not necessarily, however, give the best results with all others. Damping-off of cabbage, onion, pepper, tomato, beet, and cucumber was well and safely prevented by Tuads 0.5 gm. (Rates of application are expressed in grams per square foot in all cases.) Dithane D14, 2.5 cc., gave good results with all of these except cucumber. Dow Seed Protectant No. 9, 0.45 to 0.75 gm., gave good results with beet, cabbage, and cucumber but not with onion, pepper, or tomato; Phygon only with pepper and tomato.

Fermate and Tuads applied to soil in fertilizer immediately before seeding gave better control of onion smut than when applied in water to soil immediately after seeding. Best control of onion smut was by Dithane D14, 3.0 cc.; Phygon 0.6 gm.; or Tuads, 0.55 or 0.65 gm. With 53 percent smut in an untreated soil, there was no smut in this soil when Phygon 0.65 gm. or Tuads 0.65 gm. had been applied in the fertilizer.

Tuads 0.55 gm. or 0.65 gm. thus applied gave good control of cabbage clubroot in seedbeds and these treatments were followed by improved growth of plants.[1]

Fungicidal treatments of the seeds of *Lilium regale* were continued, tetramethyl thiuram disulfide giving the best results, and a paper was written.[2]

It was found that, lacking all fungicides, fair control of damping-off is possible by merely delaying the first watering for a few days after seeding, and the abstract of a paper read on the subject was published.[3]

Tomato Leaf Mold Caused by the Fungus *Cladosporium fulvum* Cke. (E. F. Guba, Waltham.) Tomato types developed for resistance to *Cladosporium fulvum* Cke. have been generally accepted by the greenhouse forcing industry. The most satisfactory type has been designated Improved Bay State. The resistance of Improved Bay State to tomato leaf mold was derived from a "pimpinellifolium" wild type from Ecuador designated U.S.D.A. Plant Introduction No. 112,215. The utility and resistance of Improved Bay State to Cladosporium leaf mold has been substantiated by other station workers. Confirmation of this fact by B. S. Crandall, Office of Foreign Agricultural Relations, U.S.D.A., working at Estacion Experimentale Agricola de Tingo Maria, Peru, South America, is especially significant.

Similar resistance was bred into Marglobe but the finished type lacks firm fruits and a high yielding habit. The hybrid of *L. esculentum* var. Prince Borghese X *L. peruvianum* outcrossed to Pan America, and submitted by W. S. Porte of the U.S.D.A. as No. 44B292, is being pure-lined for resistance to leaf mold and further study.

Supervision of seed production of Improved Bay State is planned, to preserve the desirable characters of the tomato for the industry. Seed samples have been distributed to interested workers in many countries.

This study, in progress since 1925, and since 1933 concerned with breeding for resistance to the disease, is nearing completion.

Causes and Control of Decay of Squash in Storage. (E. F. Guba, Waltham.) Study was made of the effect of field applications of fungicides on disease control and yield of Butternut squash. The plots were 16 x 210 feet in dimension. They were sprayed five times from August 5 to September 10.

The diseases involved were powdery and downy mildews (*Erysiphe cichoracearum* DC and *Pseudoperonospora cubensis* (B & C) Rost.) respectively, and black rot (*Mycosphaerella citrullina* (Smith) Gross.).

[1] The writer read a paper on "Fungicides applied in fertilizer for the control of cabbage clubroot and damping-off" at the Annual Meeting of the Northeastern Division of the American Phytopathological Society on November 26, 1946. An abstract will appear in Phytopathology.

[2] Doran, W. L. The protection of lilies against damping-off. National Horticultural Magazine 25:4:385-386. 1946.

[3] Doran, W. L. Control of damping-off by a delay in first watering after seeding. Phytopathology 36:8:679. August 1946.

Comparisons were made of Fermate 1½, Phygon 1, Zerlate 2, pounds in water, 100 gallons, Bordeaux 4-4-100, tribasic copper sulfate 4, and no treatment. The percentage of infected fruits in the unsprayed plots at harvest was 18.5 percent and 22.7 percent of the total. The percentage of infected fruits in the sprayed plots varied from 3.5 to 9.1 percent. The best control was obtained with Phygon.

The plots sprayed with Phygon and with copper showed the least foliage disease. The total yield and the average weight of the squash fruits were the least in the Phygon-sprayed plots.

Like numbers of squash from the sprayed plots were dipped in fungicide and combined fungicide and wax emulsions at harvest and then stored until mid-January. The least loss from black rot occurred in lots of squash from the Phygon-sprayed plots immersed in Phygon or in combined Phygon and wax emulsion, and from the Zerlate-sprayed plots immersed in Zerlate or Formalin solution. Control of rot in storage was not significant when the squash fruits from the sprayed plots were not immersed before storage. The least shrinkage from evaporation of moisture occurred among the lots of squash immersed at harvest in combined fungicide and wax emulsion.

Interrelation of Wettable Sulfur, Lead Arsenate and Lime in Apple Spraying. (E. F. Guba, Waltham.) Except for drought conditions from June 25 to July 24, the growing season was marked by continuous rains which contributed to the worst scab epidemic on record. Severe frosts caused a great reduction in the set of fruit of some varieties. Premature defoliation and discoloration of McIntosh trees from scab was prevalent.

Scab was controlled best on Delicious with Phygon and Puratized in a throughout schedule of six applications, and with a schedule of three sprays of Flotation Sulfur Paste alternating with three sprays of Puratized. Fermate gave significant control, and lime added to Flotation Sulfur Paste and lead arsenate controlled scab as well as the same mixture without lime. On McIntosh the best scab control was obtained with Phygon, Puratized, and Fermate, and significant control with Flotation Sulfur Paste and Puratized alternating. Eradication of foliage scab was best accomplished with Puratized. The action of liquid lime sulfur on the fungus was less satisfactory. Phygon and Fermate exert a marked fungistatic or inactivating action on the scab spores in foliage infections. Wettable sulfurs are not fungistatic in this respect. Fermate and wettable sulfur combined offer advantages over either fungicide alone in the control of scab.

The least amount of russeted Delicious fruit was associated with Phygon and Fermate, each combined with lead arsenate, and with wettable sulfur alone and with lead arsenate alone. Frost russeting was prevalent on Baldwin fruit among all treatments; russet ranged from 25 percent with Phygon to 70 percent with Puratized, indicating a significant influence of the spray chemical on the incidence of injury. The Phygon-sprayed trees showed abnormally colored foliage and depreciated weight of the harvested fruit.

Analysis of the sulfur residue before and after applications of sulfur indicates that the addition of lime increases the loss of sulfur from weathering. Paste sulfurs or the finest particle sulfurs weather off less than coarse sulfur.

Tobacco Frenching Induced by High Soil Temperature. (L. H. Jones and M. A. Tio.) Two varieties of tobacco—Havana Seed, a cigar tobacco, and Yellow Mammoth, a cigarette tobacco—were grown in a compost soil at two soil temperatures, a high of 95° F. and a low of 70° F. Frenching symptoms in the most extreme forms appeared on both varieties at the high soil temperature in 8 days. In 21 days terminal growth stopped, and rosetting or polyphylly was the main characteristic symptom. No frenching symptoms developed at the low soil temperature.

Parallel with the soil cultures was a series of solution cultures, at the same temperatures and with the same varieties of tobacco. The solution, Shive's R_5S_2 at 1.75 atm., consisted of KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$, with $FeSO_4$ as a source of iron. Frenching did not appear at either the high or the low solution temperature. The failure to induce frenching at the high solution temperature precludes the suggestion that root metabolism at a high temperature could be a cause of frenching. The nutrient solution was altered in several ways and various forms of iron were used in an effort to induce frenching, all with negative results. Soil extracts were obtained from frenching soils by mixing soil with distilled water and filtering. These were added to nutrient solutions but caused no symptoms of frenching.

Frenching has always been obtainable with a compost soil. To test a field soil, two tobacco field soils taken in the autumn were used for culture media parallel to the compost soil. At 95° F. the compost soil produced frenching in 14 days; field soil No. 1 in 20 days; and field soil No. 2 in 58 days in one plant of four. The field soils had been stored until February and were quite dry. Subsequent tests showed that air-drying of soil eliminated the ability to cause frenching. Autoclaving the soil for one hour at 15 pounds steam pressure also prevented frenching.

Tests made on frenched leaves showed a large amount of nitrates when it was known that there was an ample supply of nitrogen in the soil. Tests for major and minor elements, made by the floating disc method, showed a response to iron. Leaf analyses of frenched leaves showed a low amount of iron compared with normal leaves. It appears that a lack of iron in the plant seriously interfered with a proper utilization of nitrates. The osmotic concentration of the cell sap of leaf tissue of frenched leaves was above normal; 14 atmospheres for frenched leaves and 9 atmospheres for normal leaves. A histological examination of leaf tissue showed a lack of palisade tissue and spongy parenchyma in the frenched leaves.

Experiments in which iron was mixed with the soil in the forms of $FeSO_4$ mixed with peat and $FePO_4$ mixed with peat resulted in the complete prevention of frenching with the $FeSO_4$–peat mixture. Results were not so good with the $FePO_4$–peat mixture, and practically no control was obtained when either of these chemicals and peat were used separately.

When a little soil that had caused frenching was mixed with an autoclaved soil frenching was induced at 95° F. but not at 70° F. No frenching occurred in an uninoculated autoclaved soil.

The evidence now at hand indicates that at a soil temperature of 95° F. there is an effect on the soil flora which causes oxidation of iron to an unavailable form, and this oxidation takes place more rapidly than the reducing reactions which would normally maintain some iron in a ferrous form available for intake by the plants. Frenching results from a deficiency of available iron and may be prevented by supplying an excess of iron in the form of a ferrous humate made by mixing $FeSO_4$ with peat.

Resistance to Fusarium dianthi Prill. et Del., the Cause of a Serious Carnation Wilt Disease. (E. F. Guba, Waltham.) The following varieties of carnations have been crossed and self pollinated in the long effort to develop desirable commercial types resistant to Fusarium Branch Rot:

Dorothy Napier	Helen Hussey	Millers Yellow
Puritan	John Briry	Woburn
Maine Sunshine	Elizabeth Rowe	Paragon
My Love	Georgina	Hazel Draper
Eleanor	King Cardinal	Tom Knipe

These varieties were selected for selfing and crossing because of their inherent resistance to *Fusarium dianthi*. A large number of seedlings are being studied for their reaction to the disease and other characters. Two additional wilt diseases, Verticillium wilt (*Verticillium cinerescens* Wr.) and bacterial wilt (*Phytomonas caryophylli* Burkh.), have been found in eastern Massachusetts.

Toxic Effect of Wood Preservatives on Plants. (L. H. Jones.) Pentachlorphenol as a wood preservative is frequently used with range oil as a diluent. It may be easily and rapidly applied to lumber with a paint brush. When such treated lumber was covered with soil, no injury to plants was observed, even when their roots were in contact with the wood. However, when such treated lumber is used above ground, grave injury to seedlings may result from volatilization of the oil by high light intensity and high temperature coupled with poor ventilation. The injury is in the nature of a scorching due to the dissolving action of the oil on the epidermis. The injury is most severe where the treated sides of flats are higher than emerging seedlings. If the plants can grow higher than this source of the volatile substances, they are not affected by the gases.

Veneer wood plant bands strongly impregnated with range oil caused grave injury to plants when no ventilation was provided.

Miscellaneous Studies. (E. F. Guba, Waltham.)

Control of Seed Decay and Damping-off of Vegetable Seedlings by Seed-borne Chemicals. Studies have been continued to provide the vegetable growing industry with the latest information on the subject. During the year, zinc oxide, Semesan, Phygon, cuprous oxide, Arasan, Fermate, and Spergon were tested in comparison with no treatment. No one material was satisfactory with all vegetables; but for all the vegetables tested, one or more materials gave good results.

Celery Dermatitis. Many celery growers are poisoned from handling celery, especially by contact with spoiled celery caused by *Erwinia carotovora* (Jones) Comm. s.a.b. The relationship of other spoilage organisms is being investigated. A clinic was conducted by Dr. Francis M. Rackemann of Boston and his staff, in cooperation with the plant pathologist, which was attended by several celery growers. Studies are in progress in cooperation with Dr. Rackemann to learn the answers to various aspects of the problem.

Resistance to Potato Late Blight. Potato seedlings resistant to late blight, originated by Dr. F. J. Stevenson of the U. S. Department of Agriculture, were compared with standard susceptible varieties. Mohawk and Green Mountain vines were completely destroyed before September 1. The vine growth of all seedlings remained free of late blight up to October 2, when the tubers were dug. Seedlings B 69-16, B 70-5, and B 61-3 showed a trace of late blight tuber rot, and tuber infection was severe with seedling B 76-43. Seedling B 69-16 performed the best of the entire lot in every respect.

DEPARTMENT OF CHEMISTRY

Walter S. Ritchie in Charge

Factors Affecting the Vitamin Content of Milk and Milk Products. (Arthur D. Holmes.) During the past year three studies conducted under this project have been completed. All the products studied were produced locally, the ice cream and mare's milk being produced at the University. The various samples of goat's milk were obtained from prominent goat dairies located at widely scattered points in the State.

Goat's Milk as a Source of Bone-Building Materials for Infant Feeding. (Arthur D. Holmes, John W. Kuzmeski, Harry G. Lindquist, and Henry B. Rodman.) In previous studies of goat's milk attention was given to the vitamin content of commercial winter goat's milk and to the variation which occurred in the fat, ascorbic acid, and riboflavin content of individual samples of milk. Inasmuch as goat's milk is frequently used as an infant's food, it is obviously desirable to have data concerning its reliability as a source of the minerals required for the satisfactory development of an infant's skeleton. Twenty-four samples of fresh, raw goat's milk were collected at various localities in Massachusetts and southern New Hampshire. The milk was produced by four breeds of goats most common in this area; French Alpine, Nubian, Saanen, and Toggenburg. The samples were shipped to the laboratory packed in ice, and were about 24 hours old upon arrival. Average values obtained by analysis were calcium 137 mg. per 100 gm.; magnesium 17 mg.; potassium 170 mg.; phosphorus 112 mg.; fat 4.4 percent; and protein 3.4 percent. These data show that average goat's milk is a rich source of minerals and is therefore a valuable product for infant feeding. However, a final appraisal of its true value as a source of bone-building materials for infant feeding must await data regarding the extent to which infants can utilize the minerals supplied by goat's milk.

Stability of Vitamins in Stored Ice Cream. (Arthur D. Holmes, John W. Kuzmeski, and Frank T. Canavan). Ice cream has become an important component of the human dietary, about 3 gallons being consumed per capita per year. This volume of ice cream contains significant amounts of proteins, fats, carbohydrates, minerals, and vitamins. Since the proteins in ice cream are of animal origin, they have superior biological value. Only a relatively small amount of commercial ice cream is consumed at the time of its manufacture, and a question naturally arose regarding the stability of the vitamin content of ice cream during storage. Accordingly several samples of ice cream manufactured on a commercial scale in the dairy laboratory by the formula included in last year's Annual Report were stored at $-10°$ F. for seven months. Determination of the riboflavin, carotene, and ascorbic acid content of samples of ice cream before and after storage showed a 5.4 percent loss of riboflavin and a 15.7 percent loss of carotene during storage. These data indicate that the riboflavin and carotene in ice cream stored at $-10°$ F. for seven months are fully as stable as these vitamins present in a variety of canned vegetables stored for a corresponding period of time. Thirty samples of freshly made ice cream were assayed for reduced ascorbic acid, and none was detected. It is assumed that the ascorbic acid in the fresh, whole, raw milk was rapidly oxidized by the occluded air which constituted about half the volume of the ice cream.

Enhancing the Riboflavin Content of Mare's Milk. (Arthur D. Holmes.) Cow's milk is generally recognized as one of the best natural sources of riboflavin. On the other hand, as noted in last year's Annual Report, milk produced by mares that grazed in the same pastures and consumed hay grown in the same or adjacent fields as that provided for the cows, contained only about one-tenth as much riboflavin as the cow's milk. This raised the question of the comparative riboflavin content of the two types of milk and whether it would be possible to significantly increase the riboflavin content of mare's milk by feeding crystalline riboflavin as a supplement to the normal ration. Finely pulverized riboflavin crystals were diluted with a large amount of sugar pulverized to the same fineness. The homogeneous mixture was placed in No. 2 hard gelatin capsules, which are smaller than a kernel of corn but larger than an oat kernel. These were mixed with the crushed oats and readily eaten by the mares—all horses are particularly fond of sugar. A total of 5.26 gm. of riboflavin was administered to each mare

during a 22-day feeding period. The riboflavin content of the milk was significantly increased, but the increase was of short duration and the riboflavin content soon returned to pre-experimental levels. While it is possible to materially increase the riboflavin content of mare's milk, it is evidently more efficient to administer riboflavin to the foal directly rather than through the mare's milk.

A Study of the Changes in Vitamin Content Coincident with Different Stages and Rates of Maturity of Vegetables Used for Home Consumption. (Arthur D. Holmes and Carleton P. Jones.) Two studies were completed during the fiscal year. Both produced data concerning the vitamin content of vegetables—winter squash and winter tomatoes—produced locally.

Composition of Squashes after Winter Storage. (Arthur D. Holmes and Albert F. Spelman.) Squashes have been an important article of diet in this locality since early colonial times. In this study four varieties, Blue Hubbard, Butternut, Golden Cushaw, and Delicious, were secured about the middle of February from chain and independent grocery stores, private homes, and the University dining hall storage house. This represented a wide variety of storage conditions which were believed to be similar to those in general use for squashes consumed in this locality. The four varieties of squashes contained about the same amount of riboflavin. The Butternut squash had higher calcium, iron, magnesium and phosphorus content than the other varieties. The squashes contained less calcium, iron, and magnesium but considerably more riboflavin and phosphorus than was found in lettuce and kale grown on the University farm. The values for carotene, riboflavin, calcium, iron, magnesium, and phosphorus varied with the different varieties and with individual squashes within the varieties; but the results show that all four varieties, after four-month's winter storage, were good sources of food ingredients essential for the human diet. The most striking values obtained were for carotene in Butternut and Golden Cushaw squashes, for they were unusually rich in this essential food constituent.

Food Value of Hormone-Treated Tomatoes. (Arthur D. Holmes, Albert F. Spelman, John W. Kuzmeski, and William H. Lachman.) According to agricultural statistics, the commercial crop of tomatoes in 1944 was 4,051,000 pounds, which is equivalent to over 31 pounds for each man, woman, and child in this country. During recent years numerous investigators have studied the effect of spraying tomato blossoms with various plant hormones to increase the number of fruits and to produce seedless tomatoes. It is generally believed that tomato seeds have very little human food value. Accordingly, a question arose concerning the relative food value of normal and seedless tomatoes. In the present study, tomato seeds of the Waltham Forcing variety were planted December 1, and the seedlings transplanted to the greenhouse February 1. Fertilizer was applied at the rate of 20 tons of horse manure and one ton of commercial 5-8-7 fertilizer per acre. A solution of 0.075 gm. of beta-naphthoxyacetic acid per liter was sprayed directly into the center of fully opened tomato blossoms with a small atomizer until droplets of the solution could be observed inside the flower. During the interval between planting the seeds and harvesting the tomatoes, the greenhouse was exposed to 1000 hours of bright sunshine. Very little difference was found in the water content or the magnesium content of the hormone-treated and control tomatoes. The hormone-treated tomatoes averaged slightly more nitrogen, phosphorus, potassium, and calcium; but the controls contained an average of 18.2 mg. of ascorbic acid per 100 grams as compared with 14.4 mg. for the hormone-treated.

The Investigation of Agricultural Waste Products. 1. The Chemical Investigation of Lignin. (Emmett Bennett.) Continued attempts have been made to increase the nitrogen content of lignin. Oxidations with nitric acid were not particularly fruitful and have been discontinued. Attempts also have been made to unite urea and lignin. With the means at our disposal, the reaction was not successful.

The most promising procedure tried was the ammonification and simultaneous oxidation of lignin in a medium of concentrated ammonium hydroxide and oxygen at atmospheric pressure. This reaction was improved by previously subjecting the lignin to a mild hydrolysis with citric acid. Chlorinated lignin ammoniated in the above manner yielded the highest percentage of total nitrogen. The maximum content of total nitrogen obtained was about 3.9 percent.

Studies on the Quantitative Estimation of Hemicelluloses. (Emmett Bennett.) Procedures relating to the development of a method for the quantitative estimation of polyuronide hemicelluloses have been continued. The technique adopted is based on the action of sodium chlorite on plant tissue. After certain preliminary extractions, this reagent removes the lignin to almost any desired extent, leaving behind the hemicelluloses. This group of substances may in turn be removed by extraction with relatively dilute solutions of strong alkali. The extracts are then oxidized in a solution of chromate in sulfuric acid. The reduced chromate is measured spectrophotometrically. By referring to a curve which relates reduced chromate to anhydropentose, the content of hemicellulose as anhydropentose may be ascertained.

In the case of cornstalks, extractions were found to be most efficient when the tissue was mercerized with 14 percent sodium hydroxide at 20° C. for ten minutes, then an equal volume of water added and allowed to stand for a total of 90 minutes. Approximately 85 percent of the furfuraldehyde-yielding substances may be removed in this way. It is also quite probable that such a partition separates the polyuronide from the cellulosan hemicellulose. It is felt that more drastic treatment is undesirable since some pentose units might be removed from the cellulose chains. It seems more desirable to consider such units as constituents of cellulose.

Pectic compounds and ether-soluble substances should be removed prior to treatment with sodium chlorite. Starch, to some extent at least, is solubilized by the action of this reagent. Protein is not removed completely during the production of holocellulose, but is extracted almost completely by the alkaline medium; hence corrections must be applied in obtaining the final figure for hemicelluloses.

The procedure has been applied to six different plant tissues with a hemicellulose content ranging from about 7 to 25 percent. Consistent results can usually be obtained and variations between samples usually do not exceed 5 percent. It is believed that the simplicity, rapidity, and consistency of the procedure will make it of value.

The Chemical Investigations of Hemicelluloses. (Emmett Bennett.) Investigations dealing with the chemistry of hemicelluloses have been continued. Special attention has been given the hemicelluloses of cornstalks. This fraction was obtained from holocellulose prepared according to a previous report (Jour. Ind. Eng. Chem. Anal. Ed. 19, 215, 1947). To date solubility studies have been made and some of the fractions characterized by certain determinations. All solvents used extracted some hemicellulose, but the bulk was freed by the action of 4 percent sodium hydroxide at room temperature. All fractions tested were optically active and ranged from about $-60°$ to $-85°$. The more negative rotations were associated with the higher content of pentosans. Methoxyl and

uronic acids were present and decreased in amount as the content of pentosans increased. The magnitude of the alkali lability numbers would indicate that there is little difference in the chain length of the fractions obtained by use of the stronger reagents. Further interpretations are not in order at this time.

The Influence of Base Exchange Capacity and of Exchangeable Ions in Massachusetts Soils on the Availability of Potassium. (Dale H. Sieling.) Tobacco plants grown on soils of varying base exchange capacities (B.E.C.) and available potassium levels in 1942 were analyzed for calcium (Ca), magnesium (Mg), and potassium (K). Tobacco was grown on these same soils in 1946 to further exhaust the soils of cations and to determine the influence of B.E.C. on the availability of these residual bases. The plants produced were analyzed for Ca, Mg, and K.

From 50 to 60 percent of the available K was absorbed by the growing crop during the first season. The amount of K absorbed was closely proportional to the K present in the soil, and not related to the available Ca or the B.E.C. The dry weight production closely paralleled the K availability. In the second year the plants developed severe potash-deficiency symptoms and absorbed very much less K. In general, the second crop absorbed greater amounts of K from those cultures of high B.E.C.

Ca was absorbed in greater quantities from soils of high B.E.C. than from soils of low B.E.C. The relative amount of Ca to total bases absorbed was greater during the second year than during the first year. In all instances, an increase in K uptake resulted in a decrease in Ca uptake and a greater dry weight production.

The proportion of Mg to total bases utilized decreased significantly as the uptake of K increased. No significant effect on Mg uptake was shown by variations in the Ca level of the soil or the B.E.C.

There was a general tendency for the total phosphorus content of the plant material to decrease as the Mg/total cation ratio decreased.

In general, cation uptake and maximum growth was associated with soils of high B.E.C., and in turn less bases were lost by leaching from soils of high B.E.C. Therefore agronomic practices tending to increase the B.E.C. should be practical. Increase in available K in soils definitely favored the uptake of K by the plants with the subsequent decrease in the uptake of Ca and Mg. Increase of Ca, on the other hand, did not decrease the uptake of K but resulted in a higher total base uptake. The greatest dry weight production was associated with the widest K/Ca, K/Mg, and Ca/Mg ratios in the dried plant material. It therefore seems reasonable to suggest that the use of fertilizers high in K should be supplemented with liberal applications of Ca and Mg to prevent the induction of deficiencies of either of these elements as a result of luxury consumption of K.

The Fixation of Arsenic in Soils and the Influence of Arsenic Compounds on the Liberation of Fixed Phosphorus in Soils. (Dale H. Sieling.) Kaolin is a widely distributed soil mineral which has been said to have ability to fix phosphates in large quantities, especially after it has been reduced to a fine state by grinding or other means. It was found that kaolin could be activated to adsorb large quantities of either phosphate or arsenate by ball-milling it or heating it with an alkali metal hydroxide. The longer the time of ball-milling or the greater the amount of alkali hydroxide used per unit of kaolin, the greater was the sorption capacity of the activated kaolin.

The active constituent of ball-milled and alkali-activated kaolin could be removed by extracting the materials with 0.1N HCl, 0.1M tartaric acid, or 10 percent HCl. This active constituent was believed to be a hydrous alumina such

as gamma —AlOOH which is known to be present in freshly precipitated alumina and to exhibit properties similar to the ball-milled kaolin.

The alumina of ball-milled kaolin sorbed phosphate and arsenate in practically equivalent amounts from the more dilute solutions of these ions; however, from the more concentrated solutions the sorption of arsenate far exceeded that of phosphate. The amount of either anion sorbed was dependent upon the reaction of the equilibrium solution and the initial concentration of the solution. The lower the pH within the range of pH 3.0 to pH 7.0, the greater the sorption; and the higher the concentration at any fixed pH, the more of the anion was sorbed per unit of alumina.

Freshly precipitated hydrous alumina sorbed phosphate and arsenate in greater quantities than an equivalent quantity of alumina contained in ball-milled kaolin. Freshly prepared anhydrous alumina was much less active in anion sorption than the alumina of ball-milled kaolin. Aged commercial "aluminum hydroxide" had no anion sorption activity unless it had been activated by alkali and heat.

Phosphates were effective in replacing sorbed arsenate from the alumina of ball-milled kaolin, but the reaction was not an equivalent one. Arsenates replaced only a very small percentage of the sorbed phosphates from the alumina of the ball-milled kaolin even when the concentration of the arsenate was five times that of the sorbed phosphate. Therefore, the use of arsenate as an analytical reagent for measuring the anion sorption of soils or for determining the exchangeable phosphorus in soils is not recommended. It follows also that soils which have received large quantities of arsenates as a result of measures used in pest control might release quantities of arsenates toxic to plants if they were heavily fertilized with phosphatic materials.

The Effect of Orchard Mulches on Plant Nutrient Elements in the Soil. (Dale H. Sieling and Jacob K. Shaw.) Six mature McIntosh apple trees which had been managed by the cultivation–complete fertilizer system from 1931 through 1940 were selected for this study in June 1941. Six separate plots, each with an area of 1600 square feet and containing one tree at its center, were treated as follows: Duplicate plots received an application of 290 pounds, 417 pounds, 350 pounds, and 400 pounds of dry mixed-hay mulch in 1941, 1942, 1943 ,and 1944 respectively; duplicate plots received a mulch of fiber glass wool 2–3 inches in thickness in 1941; and two plots were cultivated and kept fallow. No commercial fertilizer was applied to any of the plots during the six years the investigation has been in operation.

Soil samples were taken at two systematically located positions under each tree before the mulch was applied. At each sampling location four samples were taken at the following depths: 1–3 inches, 6–8 inches, 12–14 inches, and 22–24 inches. This sampling procedure was repeated in 1942, 1943, 1944, and 1947 from newly selected positions not far removed from those of the previous year but far enough to insure the obtaining of the samples from soil which had not been disturbed by previous samplings. The mulch was removed from the sampling areas before sampling time to prevent its incorporation in the surface soil samples. The samples were stored in sealed containers and were analyzed for exchangeable calcium, magnesium, and potassium to find whether the mulching systems employed were effecting the movement of these cations into soil.

The hay used for mulching was analyzed for calcium, magnesium, and potassium and was found to vary considerably from year to year. In total, 34.3 pounds of calcium, 2.7 pounds of magnesium, and 21.7 pounds of potassium were added as mulch to each plot of 1600 square feet or at the rate of 933 pounds, 73.4 pounds, and 590 pounds of these elements per acre respectively.

The amount of these elements added as the mulch should, when the hay was mineralized, have had a significant effect upon the amounts in the upper zones of

the soil beneath the mulch, provided the tree had not effectively removed the major portions of them as the mineralization took place.

Analysis of the soils for these elements revealed that the variations between the duplicate samples obtained from the various plots during any sampling period were much greater than the variations caused by the elements added in the mulch. Therefore it is not possible to say that the mulching procedure was effective in mobilizing or increasing the exchangeable calcium, magnesium, or potassium, although trees under hay mulch were superior in performance and appearance to the trees receiving the other two treatments.

THE CRANBERRY STATION

East Wareham, Massachusetts

H. J. Franklin in Charge

Administration. Pursuant to providing acts of the legislature, considerable office changes were made in the main building of the station to accommodate increased personnel, an oil-burning plant was installed in the basement for heating the laboratory and offices, much new laboratory equipment was added, and a new full-time clerk was employed. These provisions should greatly increase the efficiency of the station and make it possible to finish in reasonable time some important lines of work that have long been in process.

General. An unusual combination of circumstances produced a large crop of cranberries in Massachusetts and the country as a whole in 1946, and there was a remarkable market demand for the fruit at record high prices. The state bog crop was the largest since that of 1923 and is returning nearly 32,000 dollars to the State Treasury.

Notable features of the 1946 cranberry season in Massachusetts were a very unseasonable frost on July 16-17 which destroyed over 1200 barrels of berries, mostly in Holliston, Plymouth, Waquoit, Santuit, Wakeby, and Brewster; and excessive rain in August (12.61 inches at East Wareham) that caused bogs to be flooded to such an extent that, as estimated, 15,000 barrels of berries were ruined. The berries of the Massachusetts crop proved to have very good keeping quality in spite of this rain.

Injurious and Beneficial Insects Affecting the Cranberry. (H. J. Franklin.) Bulletin 239 was revised and amplified and presented for republication.

DDT. Investigations made in 1946 indicated that this insecticide is effective against the cranberry tipworm and the cranberry weevil, and it was advocated as a control for these insects as well as for the gypsy moth and the black-headed fireworm in the 1947 Cranberry Insect and Disease Control Chart.

Chlordane ($C_{10}H_6Cl_8$) used both as a dust and in a spray was not nearly so effective as DDT as a control for gypsy moth caterpillars and blunt-nosed leafhoppers (*Ophiola*).

Helicopters. Observations of these machines in commercial operations against cranberry pests in the spring and early summer of 1947 lead to the conclusion that they are likely to soon come into general use on Massachusetts bogs.

Prevalance of Cranberry Insects in the Season of 1946:

1. Gypsy moth infestation moderate in Plymouth County and inland; very light in Barnstable County.
2. Leafhoppers (*Ophiola*) not very abundant.
3. Fruitworm infestation very light, rather lighter than in 1945.
4. Black-headed fireworm not very troublesome.
5. Very few fire beetles (*Cryptocephalus*) found.
6. Spotted fireworms (*Cacoecia*) very few.
7. Spanworms, both green and brown, about as usual.
8. False armyworm infestation about normal.
9. Cranberry girdler (*Crambus*) still much more troublesome than before the war, owing to neglect of bog resanding.
10. Spittle insect about as usual.
11. Tipworm apparently very much more prevalent generally than usual. Probably partly as a result of this, the average terminal budding of the vines for the 1947 crop on the bogs in this State was the poorest observed by the writer in his forty years of cranberry experience.
12. Bumblebees and honeybees were unusually abundant on the bogs everywhere throughout the cranberry flowering. A very remarkable and possibly very instructive incident relative to bee abundance was observed. The winter flowage was removed from a bog of two and a half acres in East Carver on June 20. This bog reached full bloom about August 8. Bumblebee workers and males came to this bog in astonishing numbers whenever the weather was fair throughout the blooming. It was estimated that a third of a million of these bees were there much of the time. Watching them at work, as they rose from the cranberry vines and went back to them here and then there, gave one the strange feeling that he was looking out on a bumblebee sea. Honeybees seemed to be entirely absent. The fruit, about 180 barrels of Early Black berries of fair size and color, was gathered from this bog early in October.

Frost Forecasts. These are continued as a special service, with the 1947 charges for the telephone service increased materially over those of previous years to meet the larger costs caused partly by improvements. About 7200 acres of bog in the hands of 204 subscribers are covered by the telephone warnings, this being about three-fourths of the entire Massachusetts cranberry acreage with fair to full flowage protection. The accessory warning service by radio is cooperating as heretofore with the United States Weather Bureau office at Logan Airport, the warnings being given mainly through station WEEI at Boston.

Control of Cranberry Bog Weeds. (C. E. Cross.) A large number of experiments have been set out on the State bog and other bogs since May 1, 1946, the results of which have not been previously reported.

1. In the belief that one of the greatest weed problems faced by cranberry growers is that of controlling grasses and sedges which begin their season's growth after the cranberry vines have started, many tests were made in July and August, 1946, with kerosene oils, Stoddard solvent, insecticide base oils, and a large number of strictly experimental oils known only by numerical designation. None of these oils has, as yet, proved satisfactory as a selective weed killer during the summer season.
2. Stoddard solvent, sprayed at 400 gallons per acre during the first two weeks of May has been found an excellent selective killer of asters. Kerosene at 1000 gallons per acre will not kill asters nearly as effectively, though neither treatment injured cranberry vines or buds when applied before May 15. The Stoddard solvent treatment is more effective, more easily applied, less injurious to vines,

and less expensive than the previously recommended control of asters with ferrous sulfate.

3. Paradichlorobenzene, scattered at 7½ pounds per square rod and covered immediately with an inch of sand, has previously been recommended for controlling poison ivy, chokeberry, loosestrife, and white violets. Experiments now show this treatment to be effective against wild bean (Apios) and three-square grass (Scirpus), and occasionally against the small bramble (Rubus). In addition, this treatment was found effective against poison ivy and wild bean when applied early in April while ivy and bean were still dormant.

4. Ferrous sulfate can be spread at the rate of 50 pounds per square rod without injuring cranberry vines. This heavy application, made in June, July, or August, killed all white violets, asters, and needle grass. However, serious injury to cranberry vines resulted when this treatment was applied to bogs sanded within a year. Tender cranberry roots near the surface in the new sand were apparently severely burned.

Some study and experimental work has been done toward protecting cranberry bogs from winterkilling and frost by means other than flooding. This work looks promising but is still in its preliminary stages and will not be described more fully now.

Cranberry Breeding. (F. B. Chandler, Collaborator; H. F. Bergman, U.S.D.A.) One hundred and fourteen selections from the 10,685 cranberry seedlings produced by the U.S.D.A. have been set in Massachusetts for further testing: some in four bogs, and the others in two or three bogs. From these selections, it is hoped that some new varieties will be developed which will be resistant to false blossom and fungous diseases and will give good yields of desirable fruit.

The results of the breeding work and some of the information about these selections were published in *Cranberries* for May and June, 1947.

Fertilizer Requirements of Cranberry Plants. (F. B. Chandler and Wm. G. Colby.) Plots have been laid out and fertilizer applied to study nitrate vs. ammonia as a source of nitrogen for cranberries. The rate of application of nitrogen in the treated plots has varied from 10 to 80 pounds per acre. Fertilizer applications are being made before bloom (June), before fruit-bud formation (late July), late in the fall, and early in the spring. These plots have not been established long enough to give information on yield, but vines on fertilized plots have much better vigor and bloom and are much heavier than vines on unfertilized plots on both hard-bottom and peat-bottom bogs.

DEPARTMENT OF DAIRY INDUSTRY

H. G. Lindquist in Charge

Sanitizing Agents for Dairy Use. (W. S. Mueller.) Since the last war many new sanitizing products are available for dairy use. In general these new products, both liquids and powders, have in common a quaternary ammonium salt of one form or another, which is the active bactericidal material. The effectiveness of these new sanitizing agents for dairy use is being investigated and the following progress has been made:

1. *Bactericidal Properties of Some Surface-Active Agents.* (W. S. Mueller with the cooperation of Emmett Bennett of the Chemistry Department and J. E. Fuller of the Bacteriology Department.) Results of this study were published in the *Journal of Dairy Science* 29, November 1946. It was concluded that out

of 42 surface-active agents investigated, only the quaternary ammonium salts showed considerable promise of making a good sanitizing agent for dairy use.

2. *A Method for Evaluating the Sanitizing Efficiency of Quaternary Ammonium Compounds.* (W. S. Mueller and E. P. Larkin.) A method has been developed for evaluating the sanitizing properties of quaternary ammonium compounds. While the method is not new, it involves the use of some new procedures and some refinements of older techniques. In brief, the method consists of the addition of a standardized inoculum to a germicide, and the results are simply reported as percentage survival or kill for definite periods of contact time. The usefulness of this method depends largely upon the efficiency of the inactivator. A hand homogenizer and spectrophotometer are used in preparing the inoculum, and sodium naphthuride is used as the inactivator for the quaternaries. This method appears to give a truer picture of the germicidal potency under actual working conditions than is given by the phenol coefficient values as determined by the Food and Drug Administration method.

3. *The Use of Quaternary Ammonium Compounds in Dairy Sanitation.* (W. S. Mueller and D. B. Seeley.) Organisms like *E. coli*, *S. aureus*, thermophilic types, and the vegetative cells of *B. cereus* were readily killed by quaternaries. While quaternaries appeared to have no greater germicidal effect on spores of *B. cereus* and thermodurics than older types of germicides, they were highly bacteriostatic to sporeformers.

Approximately 0.3 percent of either cow manure or non-fat milk solids produced the first significant decrease in germicidal potency of a 200 p.p.m. quaternary solution. When this concentration of quaternary was used as an udder wash under normal conditions, approximately 30 to 40 cows could be washed before the germicidal potency of the solution decreased to a point where a fresh solution was needed. No chapping or cracking of udders, teats, or milkers' hands was noted when this concentration of quaternary was used.

Metal parts of dairy equipment, when properly washed, were effectively sanitized by the use of 200 p.p.m. of quaternary. However, as much as 400 p.p.m. was not effective in sanitizing the rubber inflation tubes of teat cups after each cow milked when the cups were dipped rapidly in and out of the solution.

A quaternary spray treatment for milk cans showed a significant reduction in counts.

Dual-purpose powders such as cleaner-sanitizer combinations appear to have considerable merit.

4. *The Effect of Quaternary Ammonium Compounds on Molds.* (W. S. Mueller and R. S. McKenzie.) Considerably less work has been done with quaternary ammonium compounds in connection with molds than with bacteria. The chief purpose of this study is to determine what effect quaternary ammonium salts have on some molds commonly found in milk, cream, butter, sweetened condensed milk, and cheese. While work on this study has not progressed far enough for definite conclusions to be drawn, it is evident that not all molds are destroyed after five-minute contact with a 200 p.p.m. quaternary solution at room temperature.

Antioxidants from Cacao. (W. S. Mueller.) Improvements have been made in the extraction of certain tannin-like antioxidants from cacao, thus making it possible to obtain antioxidants of greater purity. The refined products obtained were found to be more effective than the earlier extracts in improving the stability of butter oil, according to peroxide value, color, taste, and odor tests. The refined antioxidants also were more effective in retarding the destruction of vitamin

A and in neutralizing the pro-oxidant effect of copper. If the stability data which have been obtained on butter oil by accelerated tests can be applied to food products containing butter fat, then the food value, flavor, and keeping properties of such products should be greatly improved by the use of the anti-oxidant in question.

DEPARTMENT OF ECONOMICS

Philip L. Gamble in Charge

Effects of the War and Readjustments in Massachusetts Agriculture. (David Rozman.) Further studies were made of wartime changes in the pattern of agricultural production and their effect on the needed readjustment in the coming years. Analysis of the AAA records together with other supplementary material, provided a valuable basis for determining the changes in farming enterprises on individual farms. In the light of the investigations made under this project the 1947 production program was worked out for Massachusetts agriculture.

In connection with the problems of postwar adjustment in agricultural production, an analysis has been made of the changes in major farming enterprises in the period from 1942 to 1945 inclusive. On 2374 operating farms analyzed in five counties, the following changes in livestock numbers and crop acreages occurred: All cattle and calves increased 4.9 percent; hens and pullets for laying increased 53.7 percent; corn acreage declined 8.2 percent; vegetable acreage declined 0.5 percent; potato acreage increased 16.5 percent; tobacco acreage increased 20.8 percent. This presents the situation on the farms remaining in continuous operation through the war period. To the extent that a certain number of other farms in the State might have discontinued their operation on account of difficulties in production or for some other reason, indicated changes in various lines would need some adjustment to reflect the situation on a statewide basis.

Transfer of Ownership and its Effect on Agricultural Land Utilization. (David Rozman.) Work on this project commenced at the beginning of 1947 and is yet in preliminary stages. The main objective is to appraise the effect of changing ownership on land utilization and the future trend of farming in the State. From the preliminary evidence already obtained it appears that the rate of transfer of agricultural land during the war and immediately following has been accelerated by an increased demand from various sources. The character of new ownership will have a direct bearing on the size and kind of farms and their variations from the recognized standards of an efficient economic unit. Its ultimate effect will be to determine the pattern of agricultural production as it will emerge in the State in the coming years.

To obtain a representative sample of localities for investigation, a number of towns have been considered as to their suitability. In Hampshire County, Amherst and Hatfield have been selected. From the Registry of Deeds and from assessors' records complete information was obtained as to the transfer of land ownership in agricultural areas of these towns from the beginning of 1940 to the end of 1946. In addition to land areas and names of the parties in the transactions, the information obtained includes detailed classification and valuation of property; prices paid, if given; mortgages; and the numbers and kinds of livestock maintained on the land.

DEPARTMENT OF ENTOMOLOGY

Charles P. Alexander in Charge

Investigation of Materials which Promise Value in Insect Control. (A. I. Bourne and W. D. Whitcomb.) Work in connection with the cooperative project with the Dow Chemical Company was continued in 1946, both at Amherst and Waltham.

Dormant applications of the experimental compounds D-608, D-610, D-542, D-289 and D-2 on apples, all gave excellent kill of overwintering eggs of apple plant lice. Aphids on sprayed trees averaged two or less per bud as contrasted with 50 per bud on unsprayed checks. There was also measurable reduction of European red mites on sprayed trees.

Pear psylla was very satisfactorily checked by D-542 and D-2. Eggs deposited on sprayed trees averaged less than 3 per fruit spur as contrasted with 80-85 on unsprayed trees. No further control measures were necessary on most of the pear orchard throughout the balance of the season.

D-542 on Viburnum prevented appearance of aphids on this ornamental shrub and for the first time in many years the specimens which received this spray produced a full bloom, and the unsightly appearance of distorted leaves and twigs was avoided.

At Waltham applications of experimental dinitro formulations prepared by the Dow Chemical Company were applied to 20-year-old apple trees when buds were in the silver-tip stage. The formulae were known as D-608, D-610, and D-289; and were diluted for spraying at 2 percent, 2 percent, and 2 quarts per 100 gallons respectively. Examinations on May 2 when the center bud was open showed no rosy aphis, green aphis, or newly hatched European red mite on any of the trees, including those unsprayed. Where D-610 at 2 percent was used, very slight but insignificant injury to the most advanced fruit buds was found. No injury was observed from the other formulae.

Orchard tests of a miticidal DDT containing 20 percent hydroxy penta methyl flavan were made at Waltham and in cooperation with orchardists at Bolton, Groton, and Westford, Massachusetts. When this material was used at the rate of 3 pounds in 100 gallons of spray, careful leaf counts showed a reduction in the mite population varying from 60 to 80 percent after two applications. However, red mite eggs were not killed and there was no toxic residue to prevent a serious reinfestation in two or three weeks.

DDT for Control of Black Scale on Gardenias in a Commercial Greenhouse. (A. I. Bourne.) The black scale (*Saissetia oleae*), a native of tropical and subtropical regions, occurs on many types of trees and shrubs and is one of the most serious insect pests of citrus fruits. In Massachusetts and other northern areas, it is almost entirely a pest of greenhouse plants. This scale is so prolific and has such a wide range of plants upon which it will thrive, that it is always a dangerous pest and, when well established, has proved very difficult to control. Aside from the direct damage from its feeding, the honeydew excreted by the scales serves as an excellent medium for the growth of sooty fungus. On many greenhouse crops such accumulation of black, sooty fungus on the foliage constitutes a depreciation in value second only to that caused by reduction of bloom. All these factors combine to make this species one to be dreaded by all commercial growers who encounter it in their houses.

On September 16, attention was called to a serious outbreak of black scale on Gardenias in a commercial greenhouse. The infestation occurred in both sections of one range, comprising a total of 60,000 square feet. The plants were in their second year of growth and were coming into their first season of full production. Scale was present throughout both houses but the heaviest attack was centered in the three south benches of the east house. On many plants both buds and leaves were heavily infested and much of the foliage was coated with sooty fungus. Examination of sample leaves from the house showed an average of 56.5 crawling young and 54.8 older stage scales per leaf, or a total of 111.3 scales per leaf.

On this same date a 25-foot section of one bench in the area of heaviest infestation was given a spray of a 25 percent DDT emulsion at 1:250 dilution. The rest of the eastern half of the house was sprayed with nicotine sulfate 1:500 + fish oil soap 4 pounds per 100 gallons, on September 17, 24, and at 7 to 10 day intervals thereafter.

One application of the DDT emulsion reduced the number of scales from an average of 111 per leaf to 2, within two days, and held it at approximately the same figure for three months. In the meantime weekly applications of nicotine sulfate failed to prevent an increase in the number of scales so that by late October it was necessary to make an application of DDT emulsion to the whole house to prevent serious damage to the plants. By this time, in this area, leaves and buds had become heavily infested (average 150 scales per leaf). The small number of scales in the section sprayed with DDT (average 1.6 scales per leaf) indicated how completely the pest had been controlled in that section. Both leaves and buds were practically clear of scales. The new, terminal growth was noticeably greater and the plants were in much more vigorous condition. Moreover, the DDT emulsion left no white deposit on the foliage, an objectionable feature of the use of DDT in the form of wettable powder.

The Value of Control Measures to Supplement the Standard Spray Program for Apple Pests in Massachusetts. (A. I. Bourne, in cooperation with the Departments of Pomology and Plant Pathology.) Injury from frost so reduced the set of fruit that it was necessary to rearrange the location of the spray tests.

In the orchard where the lead arsenate tests were made, the set of fruit was very light on the unsprayed check trees. They were in an exposed section of the orchard and suffered greatly from frost damage. There was also a heavy drop from disease and insect attack. All of the apples on these trees were blemished by scab; 50 percent were scarred by curculio; 67 percent were damaged by codling moth (blossom end and side worm "stings"); and about 33 percent showed scarring by minor pests and were infested by apple maggot.

The regular schedule, with lead arsenate the insecticide, held codling moth to 16 percent injury and curculio to 6½ percent, and reduced scab to 19 percent damage. When the emergency codling moth spray was interposed between the 2d and 3d cover spray, codling moth and minor insect pest damage was cut down to a mere trace, and this extra application reduced scab to 11 percent blemished fruit in a season of unusually heavy attack. The application of a mid-August spray did not give any measurable additional reduction of codling moth.

Results would indicate that if the emergency spray is carefully timed on codling moth development, no other additional spray is required, and that the increased protection from scab afforded by this spray would also justify its use.

In the orchard to which the tests with DDT were transferred, the test blocks received the regular schedule up through the calyx and first cover spray. In the

2d cover spray, all the sprayed rows received lead arsenate 2 pounds + fungicide. In addition row 1 received DDT ½ pound (actual); row 2 received DDT 1 pound; and row 7 received DDT 2 pounds. Row 5 was left as a check. In the emergency A spray and the 3d cover, the sprayed rows received the DDT as in the 2d cover, but lead arsenate was omitted. In the 4th cover, lead arsenate 2 pounds + fungicide was used, but no DDT.

Because of frost damage, the yield on the check row of McIntosh was too light to be worth considering, so that the fruit on Cortland variety was checked.

Codling moth was not as severe a pest as usual in many of the orchards in 1946, but in the DDT blocks it was practically nil (about 3 apples in 500). The heavy dosage of DDT (2 pounds actual) + lead arsenate (2 pounds) in the 2d cover spray evidently cut curculio damage materially. This conformed with results of tests in other orchards. The effectiveness of DDT was also reflected in the protection against apple maggot and miscellaneous apple pests, all of which were reduced to a mere trace; actually only a matter of an occasional apple per bushel. It was also encouraging that in a season of unusual severity of scab, the combination of DDT with wettable sulfur fungicide not only proved compatible but gave excellent protection of the fruit from scab.

Insecticides for the Control of the European Corn Borer. (A. I. Bourne.) The first brood, corn borer infestation in Massachusetts was very light in 1946 and occurred somewhat later than usual.

Cold, windy weather which prevailed through most of May appeared to be very unfavorable for moth activity. Early plantings of corn developed rather slowly, and without doubt many moths in the field emerged before corn was up or was of attractive size. This was certainly true of material in the emergence cages. Probably many moths died without depositing eggs, which seems to be borne out by the insignificant infestation on early sweet corn since there was a moderately heavy carryover and almost no winter mortality.

Throughout most of the State damage by first-brood larvae was negligible even in untreated fields. Severe drought from mid-June to late July may have contributed one factor, since considerable rolling of the leaves occurred in many fields and egg masses are easily dislodged, especially when rolling is accompanied by hot, drying winds, such as occurred in 1946. The growth of corn was slowed down and early plantings were late in maturing. Many fields planted by mid-April or earlier, and breaking ground by late April, did not mature until early August.

The second brood was also somewhat delayed and in general was not serious.

In the field tests, applications were made at 7-day intervals. Evidently this was too far apart for securing best results from derris, although it appeared to be satisfactory for the other materials. Ryanex both as a spray and as a dust gave very satisfactory control and caused no injury. Applications of DDT and DDD were followed by slight burning.

Of the sprays, Ryanex, DDT (1 pound actual), and DDD (1 pound actual) gave 98-99 percent control. Derris (4 percent rotenone) gave 95.5 percent clean corn. Of the dust materials, DDT (3 percent) gave practically complete protection, Fixed Nicotine Dust (4 percent nicotine) 97 percent, and Ryanex 94 percent.

Potato Spraying Experiments. (A. I. Bourne.) The plots were planted May 9 and the plants made normal and satisfactory progress throughout the early season. The plots were partially submerged by the heavy rains in late July when 4 to 5 inches of rain fell within about two days' time. Rains thereafter kept most of

the field rather wet and checked growth somewhat. Most of the plants remained alive and green until killed by frost October 13-14 (the first serious killing frost). The field was dug October 14. Damage from excessive water was such that records could be taken only from the higher portion of the field.

Flea beetles were slightly less than normal in abundance; the early attack was very light. A rapid and heavy build-up of leafhoppers occurred between July 17 and 25. One application of DDT (1 pound actual) in 10-5-100 Bordeaux on the 25th not only practically eliminated leafhoppers but wiped out the late brood of flea beetles; neither insect was present in any amount for the remainder of the season. Potato aphids began to appear in all plots about mid-July during the hot dry weather which prevailed at that time. The infestation was subdued with nicotine sulfate in the application of July 17. The records indicate that the application of DDT practically eliminated insect pests with the exception of potato aphids, and even in the case of potato aphids prevented a serious build-up. By mid-August practically all insects had been eliminated and the insignificant damage to foliage was shown by records of flea beetle perforations on the foliage: 6.4 punctures per growing tip on August 17 and 2.5 punctures per growing tip on August 20.

Sprays were applied at approximately 7-day intervals from June 12 when the plants were about 4 to 6 inches high until September 18 when most of the plants were still green but were beginning to ripen. The sprays from August 28 were for protection of green tips only. There was practically no evidence of insect presence after early August.

Evidence from these tests, as well as results of experiments elsewhere, indicate tnat DDT is very effective against the major insect pests of potato. In laboratory and field tests, DDT either as a dust or as a spray controlled Colorado potato beetle, leafhoppers, flea beetles, and plant bugs, if thoroughly applied to reach both upper and under leaf surfaces. There is indication that potato aphids can be held to low numbers by a regular schedule of DDT, although there is still some doubt whether heavy outbreaks will be checked quickly enough to prevent damage when DDT dusts or wettable powders are used.

Control of Onion Thrips. (A. I. Bourne.) The test plots were planted to onion sets April 18. Cool dry weather slowed early development somewhat, but with plentiful rainfall in May and early June, growth was more normal and the plants made rapid advance. The growth was checked somewhat by the 5-week period of dry weather which followed. The plants had become well established by mid-June so that the check was not serious, and the plots matured a good crop which was ready to harvest by early August.

Thrips were delayed somewhat in early spring by the cold weather but found the hot dry weather of late June and July very favorable, and built up rapidly. Throughout the Connecticut Valley, thrips were not of serious abundance; set onions escaped any appreciable injury, and the small plantings of seed onions were not seriously attacked.

Black Leaf 40 and derris sprays again gave consistently high control in all cases. Ryanex, DDT, and DDD sprays also proved effective (above 90 percent effective control). DDT and DDD were superior to the other sprays in residual effects, allowing no increase in thrips population during a 7-day period following application.

Of the dusts, Multicide and Multicide + pyrethrum gave a consistently high degree of immediate protection and good residual effects. Following a very heavy

application, sabadilla gave very good control but appeared to have very little residual value. Ryanex dust appeared to kill rather slowly but to furnish good lasting effects. DDT dusted plants showed even fewer thrips after a 7-day interval than 24 hours after the application.

None of the sprays or dusts used caused any plant injury.

Control of Squash Vine Borer. (W. D. Whitcomb, Waltham.) Experimental plantings in 1946 verified previous observations that varieties of *Cucurbita moschata* are immune to squash vine borer. Three varieties of *C. maxima* averaged 2.88 borers per vine, and three varieties of *C. pepo* averaged 1.70 borers per vine.

Insecticide applications in July with 3 percent DDT–talc dust, 20 percent sabadilla–lime dust, and ½ percent DDT plus 0.06 pyrethrins dust gave satisfactory protection; while applications of 10 percent sabadilla–lime dust and ½ percent DDT–talc dust were unsatisfactory as used.

A 5 percent benzine hexachloride-talc dust applied while the plants were small caused so much injury that it was necessary to replant. The 3 percent DDT-talc dust caused slight temporary stunting to seedlings, which was most evident on cucumbers and least evident on Blue Hubbard squash.

Control of Cabbage Maggot. (W. D. Whitcomb, Waltham.) Field treatments for the control of the cabbage maggot in early Golden Acre cabbage were compared with a natural 100 percent infestation on untreated plants, in which 84 percent of the plants were commercially damaged. DDT–talc dust, both 3 and 5 percent DDT, applied either with a hand duster in two applications at a weekly interval, or placed in a mound around the stem of the plant soon after the first eggs were laid, permitted 20 to 25 percent infestation and from 20 to 40 percent of the heads were unmarketable. Corrosive sublimate solution 1–1,280 in two applications, and 4 percent calomel–talc dust in a mound around the stem gave perfect protection from commercial injury. However, the outstanding treatment was two applications with a hand duster of benzene hexachloride–talc dust containing about 5 percent of the gamma isomer. This dust completely controlled the maggot on both cabbage and cauliflower as well as preventing blind heads due to cutworm injury. No evidence of contamination by the odor of the insecticide was evident at any time after the heads began to form. This treatment promises to have great commercial application.

Biology and Control of Red Spider Mite on Greenhouse Crops. (W. D. Whitcomb, Wm. Garland, and C. S. Hood, Waltham.) Spraying of greenhouse roses with hexa ethyl tetra phosphate solution resulted in excellent control of greenhouse red spider, but caused some injury to foliage and stunted the growth of the petals on the outside of rosebuds. Two commercial brands of this material diluted as recommended were equally effective and caused similar plant injury.

The effect of sodium selenate in red spider control was studied on potted carnations at low temperatures (55° F.) during the winter. Dosages of ½ gram, ¾ gram, and 1 gram per square foot caused a reduction in the spider population 50 days after treatment, and remained effective for 50 days longer (100 days after application). A dosage of ¼ gram per square foot became noticeably effective 60 days after application and remained effective only 30 days. Spider populations were not reduced as much by the dosages used as they were by similar treatments in spring and summer.

Apple Maggot Emergence. (W. D. Whitcomb, Waltham.) Apple maggot fly emergence in cages at Waltham occurred at about the normal period in 1946 although the number of maggots which survived the winter and transformed was low. Emergence peaks occurred at two periods, July 7 and 25, which verified the estimated dates for control by spraying. The emergence in two orchard cages was:

First fly emerged	June 29, 1946
25 percent of flies emerged	July 7-11
50 percent of flies emerged	July 14-22
75 percent of flies emerged	July 24-27
Last fly emerged	August 20
Percent of expected emergence	68.8
Percent of possible emergence	34.1

Control of Plum Curculio in Apples. (W. D. Whitcomb, Waltham.) Although laboratory poison studies with plum curculio beetles confined with sprayed apples indicated reasonable control with DDT water suspensions containing more than 1 pound DDT per 100 gallons, orchard experiments with 1½ pounds DDT per 100 gallons were unsatisfactory. Two commercial brands of DDT wettable powder were compared, with almost identical results; namely, 48.47 and 48.54 percent of the apples stung by curculio.

A 50 percent hexachlorocyclohexane wettable powder containing 5+ percent gamma isomer combined with wettable sulfur failed to control the plum curculio (61.06 percent total fruit and 49.91 percent harvest fruit stung), when used in the regular schedule of applications. It was evident from observations, however, that more frequent applications would have been significantly more effective. Each of the following combination treatments was significantly more effective than lead arsenate alone in the same schedule, as shown by the percentage of harvest fruit free from stings.

Lead arsenate	4 pounds	75.71
Lead arsenate	4 pounds + DDT 50 wettable 2 pounds	97.31
Lead arsenate	2 pounds + DDT 50 wettable 2 pounds	87.62
Lead arsenate	4 pounds + BHC 50 wettable 2 pounds	86.90
DDT 50 wettable	2 pounds + BHC 50 wettable 2 pounds	86.51

This is the second season when sprays containing combinations of insecticides have been outstandingly effective for control of the plum curculio, and significant evidence of their practical value is rapidly accumulating.

Naphthalene and Similar Compounds as Greenhouse Fumigants. (W. D. Whitcomb and Wm. Garland, Waltham.) Several materials were used experimentally for the first time in an effort to find a fumigant which was effective against both greenhouse red spider and aphis.

The most promising fumigant was prepared by adding small amounts of the pure gamma isomer of $C_6H_6Cl_6$ to commercial Fulex paste. Addition of 1.24 percent, 2.48 percent, and 4.96 percent gamma isomer were equally effective and gave complete kill of aphids while retaining the usual high kill of red spider from Fulex.

Pressure fumigation cans containing 17.5 percent azobenzene were very effective against red spider and practical in spite of slight bleaching of pink flowers. The addition of 10 and 16 percent azobenzene to Fulex paste was slightly less injurious than the azobenzene, and effective.

Other materials were discarded for reasons indicated:

Amino azobenzene—effective, but left disastrous yellow residue.
Isopropoxyl diphenyl amino—ineffective.
Vultrol (U. S. Rubber Co.)—ineffective.
Dichloraniline—effective but caused severe plant injury.
$C_{10}H_6Cl_8$ (Velsicol) ½ ounce–1,000 —ineffective as used.

Biology and Control of the Celery Plant Bug. (W. D. Whitcomb and Wm Garland, Waltham.) The results of the insecticide experiments on the celery plant bug in 1946 show that nearly all of the materials used killed the bugs well and eliminated them from the plants immediately after treatment. From the standpoint of lasting protection, however, the sprays of DDT wettable powder were outstanding and no bugs were found on the count plants in these plots for the remainder of the season.

From a practical standpoint, 1 pound of 50 percent DDT wettable powder in 100 gallons of spray (½ pound actual DDT) was as effective as the 2 pound–100 gallon dosage. DDT–talc dusts containing 3 and 1 percent were effective for a month and gave good protection from black heart; but ½ percent DDT dust apparently requires applications at 10–15 day intervals to give adequate protection. Dry Pyrocide 7½ dust is also effective but requires more frequent applications. Special Multicide (½ percent DDT and pyrethrum) was the most effective dust used, with 97.94 percent of the plants free from black heart injury, and was very promising under the conditions of the experiment. Applications of this dust at 30-day intervals should be satisfactory. Sabadilla–lime dust 10 percent gave protection for only a few days.

Based on these experiments, practical control of the celery plant bug, *Lygus campestris*, and the resulting black heart injury should be obtained by spraying about August 10 with ½ pound of DDT (1 pound 50 percent DDT wettable powder) in 100 gallons of water or fungicide, and if necessary following with Dry Pyrocide 7½ dust about September 20 when the second generation of the plant bugs is most abundant.

The use of DDT on celery involves a residue tolerance which has been set, at present, by the U. S. Food and Drug Administration at 7 parts per million. Analyses to determine the relation of the effective treatments to the residue tolerance will be made as soon as possible.

Biology and Control of the Grape Cane Girdler. (W. D. Whitcomb and Wm. Garland, Waltham.) On unsprayed grape canes, grape cane girdler beetles lived an average of 114.2 days and made 18.8 scars per beetle. Sprays of DDT wettable powder killed the beetles in 2.57 days and reduced the scars to 0.23 per beetle. There was no significant difference in effectiveness of ½, 1, 2, 3, or 4 pounds actual DDT per 100 gallons, and DDT was equally effective when combined with basic copper sulfate or Fermate. Benzene hexachloride 50 percent wettable powder containing 6 percent gamma isomer was also effective, at the above dosages, when repeated after 5 days. Lead arsenate was slightly less effective at dosages of 3 or 4 pounds per 100 gallons. The most effective treatments were combinations of DDT, 1 pound actual, with 2 pounds of benzene hexachloride as above, or with 2 pounds of lead arsenate per 100 gallons of water.

In the vineyards, prevention of girdled canes and other injury was more dependent on spraying whenever the canes increased their growth about 6 inches than on the insecticide formula used.

Sprays to Prevent Scolytid Infestation of Elm Logs. (W. B. Becker.) At Springfield, a number of sprays including different concentrations of DDT (dichloro-diphenyl-trichloroethane) and DDD (dichloro-diphenyl-dichloroethane) were applied once (May 14 to 16) to the entire bark surface of elm logs before scolytids could attack them in the spring. Each test involved 20 to 31 square feet of bark with a maximum thickness between 3/8 and 7/8 of an inch. The percentages of prevention were based on the number of exit holes found per square foot of bark in the late fall, compared with those in unsprayed logs. In each instance the quantity of spray applied was what the operator estimated to be necessary to thoroughly wet the surface of the bark (58 to 166 ml. per square foot). *Scolytus multistriatus* Marsham was much more abundant than *Hylurgopinus rufipes* (Eich.) in both sprayed and unsprayed logs.

No. 2 fuel oil alone gave 100 percent prevention, as did also orthodichlorobenzene and No. 2 fuel oil, mixed 1 to 8 by volume. DDT solutions in No. 2 fuel oil, at concentrations between 0.0625 and 5.0 percent actual DDT, gave 99.7 to 100 percent prevention. A 50 percent DDT wettable powder in water gave 74.6 percent prevention at 0.0625 percent DDT, 95.4 percent at 0.125 percent DDT, 97.4 percent at 0.25 percent DDT, and 100 percent prevention in concentrations containing from 0.5 to 5.0 percent DDT. A 25 percent DDT emulsion in water gave 98.5 to 100 percent prevention in all concentrations used, from 0.0625 to 5.0 percent actual DDT. A 25 percent DDD emulsion in water gave 70.6 percent prevention at 0.0625 percent DDD, 95.1 percent at 0.125 percent DDD, 94.8 percent at 0.25 percent DDD, 98.3 percent at 0.5 percent DDD, 99.5 percent at 1.0 percent DDD, and 100 percent at 3.0 and 5.0 percent DDD.

Sprays to Kill Scolytids Breeding in Elm Logs. (W. B. Becker.) At Springfield, DDT and DDD sprays at the same concentrations used for the preventive applications were applied once to elm logs in an attempt to control established scolytid infestations. Relatively light applications (between 27 and 53 ml. of spray per square foot of bark) were made on June 11 to recently cut elm logs soon after the scolytids attacked them. Beetle emergence commonly starts about the first of August from such logs. Because of the timing of the applications, the spray residues weathered for the longest period of time which would ordinarily be required in any one growing season. Each test involved 27 to 31 square feet of bark of a maximum thickness of 5/8 to 1 inch. In these, as in all other spray applications, the sprayed logs were covered with a single layer of other logs to avoid larval mortality from high subcortical temperatures caused by the rays of the sun.

There was no apparent relationship between the strength of the sprays used and the number of brood galleries constructed in the various sets of logs. Based on the number of empty exit holes per brood gallery in the autumn, the DDT sprays gave no control at the lower concentrations and mostly poor control at the higher concentrations. At 5 percent DDT, the oil solution gave 81.5 percent control, while the wettable powder and emulsion sprays gave approximately 54 percent control. The DDD sprays gave no control.

Best results were obtained with the higher concentrations of DDT in oil solution, possibly because of the presence of the oil, which causes mortality by itself when applied in sufficient quantities; and possibly because the DDT was carried down into the bark by the oil solution and so killed beetles before they could reach the surface. Probably the DDT in water emulsion and especially the

DDT in water suspension remained at the surface of the bark to a greater extent and so permitted more adults to tunnel out to the surface.

It was interesting to note, however, that as the concentration of DDT and DDD in the sprays was increased, usually a higher percentage of adults was found dead in exit holes in the autumn, a phenomenon which has not been observed to result from the types of sprays tried previously. This suggests that some emerging adults were killed by the DDT and DDD spray material they encountered very close to or at the surface of the bark. No one type of DDT spray proved to be consistently superior, in this respect, to the others at the several concentrations used in these tests.

To what extent DDT caused mortality among the adults which completely emerged from the bark was not determined. It would no doubt be influenced by the amount of DDT residue remaining effective on the surface of the bark when they emerged and by the extent to which the adults crawled around on the bark immediately after emerging. The extent of this crawling may be influenced by the environmental conditions on the surface of a log.

Preliminary Spraying Experiments to Prevent Twig Feeding by the Smaller European Elm Bark Beetle. (W. B. Becker.) Feeding on live elm twigs by the smaller European elm bark beetle (*Scolytus multistriatus* Marsham) after it emerges from dead elm bark is at present believed to be one of the more important methods by which the fungus which causes Dutch elm disease, *Ceratostomella ulmi* (Schwarz) Buisman, is introduced into living elm trees. Since twig feeding may occur from spring to autumn, it is desirable that any preventive spray should give protection for as long as possible, to keep the number of spray applications at a minimum. Some of the newer types of spray materials which leave a deposit having a relatively long residual effect were used in attempts to reduce the amount of such twig feeding. Commercially prepared DDT and DDD sprays were used in concentrations between 0.0625 percent (which is slightly less than the strength used to combat defoliating insects on living plants) and 5.0 percent (which is the strength commonly used for some household pests where spray injury to plants is not a problem.

Sprays were applied directly to low branches of living American elms, *Ulmus americana* L., until or almost until the spray began to run off. Three series of applications were made, each on different elms *in full foliage*, two series in June and one in August. A three-gallon compressed air sprayer was used with a Mohawk adjustable nozzle which gave a cone-shaped spray pattern. Feeding tests were run in the laboratory with freshly cut twigs from sprayed elms placed in gallon size glass jars with newly emerged beetles. Control estimates are based on a comparison between the number of punctures which reached the cambium of sprayed and unsprayed twigs kept in separate jars.

At spray concentrations near those now used for defoliating insects prevention of *S. multistriatus* twig feeding did not last as long as would seem desirable. As the concentrations were increased, much more lasting protection was obtained, but unfortunately the foliage injury to elms caused by the DDT emulsions increased to an undesirable point, and injury to hard maples and some other plants on which the spray drifted was even greater. While the DDT wettable powders caused no injury worth mentioning, the spray deposit left by the higher dosages was quite noticeable and the nozzle frequently clogged. Mites also caused some very noticeable browning of the sprayed leaves, as other workers with DDT have reported. Such high spray concentrations would cost correspondingly more than the lower strengths commonly used for defoliating insects.

At comparable strengths, the DDT emulsions lasted longer than the DDT wettable powder sprays; and as far as the test went, the DDD emulsions seemed to give results somewhat below those obtained with the DDT wettable powders.

In the early spring of 1947, several commercial DDT emulsion concentrates were applied while the trees were still dormant, at strengths up to 2.0 percent DDT, and no noticeable injury to the elms was observed. The long-term residual effects of these spray deposits are being studied, as is also the possibility of beetles feeding on the new unsprayed twig growth which appears after the dormant spray application.

Future studies may reveal whether laboratory feeding tests such as these approximate what might actually happen in the field where the beetles can move about freely, and to what extent the occurrence of Dutch elm disease will be affected by the reduction of this twig feeding.

Use of a Mist Blower to Apply Concentrated Sprays to Elms to Prevent Twig Feeding by the Smaller European Elm Bark Beetle. (W. B. Becker.*) A new Buffalo turbine blower was used to apply DDT to large elm trees in the forms of concentrated (up to 15 percent) oil solutions and water emulsions. The spray nozzle was altered so two cone-shaped jets of spray were ejected into the high velocity air current in the mouth of the blower. An output of as little as nine gallons of spray per hour could be applied.

Preliminary experiments with this mist blower resulted in relatively long lasting prevention of *S. multistriatus* twig feeding in the lower portions of an elm (20 to 25 feet from the ground) when sufficient spray was directed at the tree. However, in the upper portions of medium-sized elms (60 to 65 feet high) protection was often relatively short, even when one and two gallons of a 12 percent spray were applied to one such elm. When dosages were near those used to combat defoliating insects (approximately one quart of a 12 percent DDT spray), long-term protection against *S. multistriatus* twig feeding was often not satisfactory even on the low branches 20 feet from the ground. Freshly cut twigs from different heights in the elms were tested in gallon size jars as described under the preceding title.

Preliminary experiments with this mist blower point out that for reaching the tops of shade trees best results are obtained when there is no wind movement. Naturally, when using such strong insecticides, even in mist form, one must avoid getting too close to the plants, and also avoid putting on an excess of the spray mist; otherwise plant injury may result.

Experiments are being continued with different types, strengths, and volumes of spray.

*The author is indebted to entomologists at the Field Headquarters, Gypsy and Browntail Moth Control, of the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, at Greenfield, Mass., for much helpful information about mist blowers and their operation.

FEED AND FERTILIZER CONTROL SERVICES

John W. Kuzmeski in Charge

The feed, fertilizer and milk testing laws are administered as one service and the operations of each, with the exception of the milk testing law, are reported in annual bulletins.

Under the milk testing law 11,089 pieces of Babcock glassware were calibrated and 191 certificates of proficiency in testing were issued. All milk depots and

milk inspection laboratories in the Commonwealth were visited at least once to check apparatus and general conduct of the work.

In addition to the regulatory work the Feed and Fertilizer Control laboratories have examined feeds, fertilizers and other agricultural materials for citizens of the Commonwealth without charge whenever the results were considered of interest to the general public or to the Control Services.

Considerable work has been done on research projects in cooperation with other departments of the University and Experiment Station. The results of such work are reported by the departments originating the projects.

DEPARTMENT OF FLORICULTURE

Clark L. Thayer in Charge

Breeding Snapdragons for Variety Improvement and Disease Resistance. (Harold E. White, Waltham.) The variety Helen Tobin and a pink-flowered inbred line P-41 intercrossed yielded progeny that was 90 to 100 percent resistant to rust under field conditions. Hybrid progeny from these crosses was more vigorous than the parent lines and more uniform as to flower colors. The P-41 strain is resistant to rust and transmits this character readily to rust-susceptible varieties when crossed with them.

A number of samples of seed from the Field Station hybrids have been distributed to local growers. Several growers have reported that the hybrids are an improvement over many of the commercial varieties and that cut blooms from them have brought better monetary returns.

Six of the Field Station hybrid lines were tested in California where they did not prove to be resistant to Form 2 of the snapdragon rust, even though they were resistant to Form 1 which is prevalent in Waltham.

Strains of snapdragon from Waller Franklin Seed Company, Guadalupe, California, were tested at Waltham and found to be highly resistant to the form of rust present here. However, they are not as free flowering as the Field Station strains.

Subirrigation Methods of Watering Carnations. (Harold E. White, Waltham.) Three different systems of applying water to subirrigated benches were studied: constant water level with regulation by a float valve, manual injection, and automatic injection.

The automatic injection method was of two types, whereby (1) a solenoid valve was operated through a relay and time clock, and (2) a solenoid valve was controlled through a pneumatic and a pressuretrol control regulated by means of a stoker timer. This pneumatic system was connected to an air pressure thermostatic control unit used to operate the greenhouse heating system. Soils were watered by manual and automatic injection systems when between 2 and 3 pounds vacuum pull in the soil showed on the tensiometer vacuum gauge.

Investigation of the pneumatic system of automatic water injection is being conducted through cooperation with the Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota.

Varieties of carnations used in the tests were: Weld, Northland, Tom Knipe, Hercules, Salmon Virginia, and Dark Pink Virginia. The soil, which had been used for carnations the previous year, was sterilized with steam.

Carnation plants made equally good growth under all three methods of watering. Flower production on the differently watered benches did not vary significantly. Splitting of the blooms was not noticeably affected by the different methods of watering. The plants grew and produced equally well in ground concrete beds and in raised concrete benches.

Roots of carnation plants grown under subirrigation methods do not penetrate the gravel layer beneath the soil to any great degree. Examination of plants carefully removed from such benches showed that the roots mat in a layer at the junction of soil and gravel level, closely comparable to the condition that occurs with roots of plants grown in clay pots.

Observations of top-watered benches in commercial ranges where carnations are grown show that, in comparison with subirrigation methods of watering, carnation plants are in greater danger of being inadequately supplied with water rather than of being over-watered, as most growers fear. This is particularly true during summer months, early fall, and spring.

Losses of plants from stem, root, or branch rots were not observed to be any more prevalent under constant water level methods than in manual or automatic injection systems of watering.

Sodium Selenate as a Red Spider Control. (Harold E. White, Waltham.) The use of sodium selenate for red spider control by commercial flower growers in the State continues to increase. This past year between 40,000 and 50,000 pounds of P-40 were used by carnation and chrysanthemum growers in Massachusetts. The P-40 is granular superphosphate impregnated with 2 percent of sodium selenate and is the popular form used since it can be applied to bench soils as readily as fertilizer. Growers of bench crops have shown greater interest in sodium selenate than growers of pot plants.

A few growers of hardy chrysanthemums have tried sodium selenate for control of foliar nematode, a disease that has become more common in hardy chrysanthemum plantings outdoors.

Experiments so far at Waltham have been confined to the use of sodium selenate as a method of insect pest control from the viewpoint of commercial application. From these tests certain information has been derived, and problems have arisen that indicate a need for more detailed investigations.

Rooting of Carnation Cuttings in Subirrigated Sand and Vermiculite. (Harold E. White, Waltham.) Cuttings of ten varieties of carnations were used for rooting tests in Vermiculite (mica), subirrigated and top-watered, and in sand, subirrigated and top-watered. The ¼-inch and ½-inch grades of Vermiculite were compared as rooting media, as were mixtures of sand and Vermiculite; but appreciable differences were not distinguished in the use of the two sizes of Vermiculite.

When root formation on cuttings rooted under the different treatments is evaluated in terms of excellent to good, the ratings in percentage of rooting are as follows: sand subirrigated 71; sand top-watered 75; Vermiculite subirrigated 72; and Vermiculite top-watered 83.

When all the rooted cuttings of a treatment are grouped together without classification, the results are: sand subirrigated 77 percent; sand top-watered 90 percent; Vermiculite subirrigated 81 percent; and Vermiculite top-watered 90 percent rooted.

The results of these tests show that a mixture of sand and Vermiculite when top-watered produced a higher percentage of rooted cuttings than similar media

subirrigated. However, even though sand top-watered was comparable to Vermiculite in percentage of cuttings rooted, the roots formed in the Vermiculite were 50 percent greater in length and more numerous on individual cuttings. Initiation of roots on cuttings in the Vermiculite does not appear to occur sooner than in sand, but roots grow much more rapidly once they are formed. This striking difference in rate of growth between roots produced in the two media probably is due to a more uniform supply of available moisture to the roots in Vermiculite. Also, there is better aeration due to less tendency of the Vermiculite to pack.

Since cuttings transplanted from a rooting medium such as Vermiculite have roots with thinner cellular tissue, the soil into which the roots are placed must be kept more moist until they have become established in it.

Dusting China Asters with Insecticides for Control of Yellows. (Harold E. White, Waltham.) During the summers of 1945 and 1946 various kinds of insecticidal dusts were applied to China Asters under field conditions to determine the effectiveness of such treatments in control of leafhoppers which carry the yellows disease.

In 1945, test plots were dusted at 7 to 10 day intervals with a 2½ percent DDT–sulfur dust and a 5 percent DDT–sulfur dust. Two formulations of each of these dusts were used, one being a fused DDT-sulfur and the other a mechanical mixture of DDT–sulfur.

The treatments in 1946 were along similar lines with 1 percent DDT, 3 percent DDT, sabadilla 10 percent, pyrethrum dusts, and a formulation known as X 155 which contained 12 percent nicotine and 7 percent DDT.

Tests made with these different insecticidal materials on living leafhoppers confined in a cage showed them to be toxic to the insects. However, the field tests made by dusting China Aster plants in the open yielded no significant data insofar as reduction of the yellows disease was concerned. Apparently these dusts, as used under field conditions, were not sufficiently repellent to prevent leafhoppers from feeding on plants and transmitting the yellows virus.

From these tests, it would seem that insecticides applied to asters in order to control yellows must be of a highly repellent nature to keep the leafhoppers from the plants.

DEPARTMENT OF FOOD TECHNOLOGY

C. R. Fellers in Charge

Incidence of Home Canning Spoilage Bacteria in the Soil. (W. B. Esselen, Jr., G. K. Lycarzyk, and C. R. Fellers.) During the summer of 1945, 325 samples of soil and raw vegetables were obtained from 15 gardens of Amherst and vicinity; and in 1946, 671 samples were collected from 12 gardens of the same locality. The samples were examined bacteriologically in order to study the incidence and factors influencing the incidence of thermophiles, putrefactive anaerobes, and flat sour organisms, these being representative of important groups of spoilage bacteria encountered in home canning.

These three groups of bacteria showed considerable variation in numbers during the season. Rainy weather seemed to favor their development. In general, the number of thermophiles present in the soil samples greatly exceeded the numbers of putrefactive anaerobes and flat sour organisms. Gardens treated

with fertilizers of various kinds tended to show higher counts of the organisms studied than did untreated gardens.

Stability of Riboflavin in Processed Foods. (W. B. Esselen, Jr., J. E. W. McConnell, and J. P. Crimmins.) Studies of factors which influence the stability of riboflavin in canned foods, packed in glass or metal containers, have been continued. Experimental packs of green beans and of synthetic solutions of riboflavin in cans and glass jars were prepared so that the effects of acidity, added iron, tin, ascorbic acid, sodium bisulfite, and sodium dichromate could be observed. Changes in the riboflavin content of these different packs during storage were determined. The results to date are all in general agreement and indicate that the stability of riboflavin in processed foods may be influenced to some extent by the relationship of oxidizing and reducing conditions present in the product and container. The presence of a relatively small proportion of ascorbic acid or tin (stannous chloride) tended to cause a greater loss of riboflavin during storage than occurred in control samples; but when the proportion of ascorbic acid or tin was increased, it tended to reduce the loss of riboflavin, particularly in an acid medium. The addition of iron (10 and 100 p.p.m. of ferrous chloride) to glass-packed green beans and synthetic riboflavin solutions had little or no effect on the stability of riboflavin.

The Use of Calcium Chloride to Maintain Firmness in Canned and Frozen Apples. (W. B. Esselen, Jr., and W. J. Hart, Jr.) The effectiveness of treatment with calcium chloride in retaining the firmness of canned and frozen sliced McIntosh and other varieties of apples has been reaffirmed. September through December were found to be the best months for freezing McIntosh apples. When held in cold storage for longer periods, this variety reached a point where the use of calcium chloride was no longer effective in maintaining firmness.

After the apples are peeled, cored, and sliced, the slices may be readily treated by dipping them in a dilute solution of calcium chloride (U.S.P. grade). The strength of the solution required will depend upon the variety and condition of the apples, the time of dipping, and the ultimate degree of firmness desired. Under most conditions a five-minute dip in a 0.1 percent calcium chloride solution was found to yield a very satisfactory product. In many cases the calcium treatment can be combined with the treatment used to prevent darkening.

Calcium chloride was found to be effective as a firming agent for fifty varieties of apples when they were canned or frozen. With apples that were quite firm initially, there was no advantage in using the calcium treatment, and in some cases the treated slices may be objectionably firm and rubbery.

Laboratory and commercial tests have indicated that sliced McIntosh and Wealthy apples may take up calcium in amounts ranging from .019 to .054 percent calculated as anhydrous calcium chloride, with average values of .030 to .045 percent. While there has been no official ruling on the use of calcium salts for firming apple slices, it may be noted that under the Federal Food and Drug Administration Regulations it is permissible to add up to 0.07 percent of calcium chloride to canned tomatoes to aid in maintaining their firmness.

Home Freezing. (W. B. Esselen, Jr., J. E. W. McConnell, N. Glazier, and C. R. Fellers.) A bulletin on home freezing has been prepared and printed. It is based on work carried on here and by other agencies and contains information on such phases of home freezing as economics, comparison with home canning, freezer operation, varieties of fruits and vegetables for freezing, technics, and a discussion of the importance of home freezing in Massachusetts.

Work was continued on the quality of different varieties of fruits grown in this area when frozen by home-freezing methods. Samples of fruits were provided through the cooperation of the Department of Pomology. The products frozen during the 1946 season included 11 varieties of strawberries, 4 of raspberries, 15 of plums, 2 of currants, 9 of cultivated berries, and 26 of peaches. This variety investigation is being continued during 1947 in order to obtain additional information over a period of several seasons.

The addition of small amounts of ascorbic acid to home-frozen peaches was effective in improving the color and flavor of the finished product.

In the course of other investigations, during the past five years, approximately 10,000 jars of fruits, fruit juices, vegetables, meats, fish, and poultry have been frozen under typical home-freezing conditions. Glass containers are satisfactory for home freezing as they provide a moisture-proof container which can be re-used many times. No trouble from breakage has been encountered. The chief objection to glass jars is that inherent in all round containers; they waste space in the freezer, as compared with square-sided containers. This disadvantage would probably be offset by the advantages in many cases.

Nutritive Value of Cultivated Mushrooms. (C. R. Fellers, J. E. W. McConnell, and W. B. Esselen, Jr.) A five-year investigation of the nutritive value of cultivated mushrooms (*Agaricus campestris*) has been completed and the results summarized in Experiment Station Bulletin 434 which was published last summer. Data were obtained on the proximate composition; protein, carbohydrate, and vitamin content; and the effect of cooking, canning, dehydrating, and freezing on their "B-vitamin" content. Mushrooms were found to be excellent sources of certain of the B vitamins, such as riboflavin and nicotinic acid. They also contain approximately 2.6 percent of protein and all of the essential amino acids, at least in small amounts.

Jar Rings for Home Canning. (W. B. Esselen, Jr.) An investigation of factors which influence the quality of jar rings for use in home canning, initiated in 1943 in cooperation with the jar ring industry, the Department of Agriculture, and other Government agencies, is being continued. Tests completed in August 1946 indicated that the use of natural rubber in place of synthetic rubber (both in combination with reclaimed rubber) did not necessarily produce jar rings which were free from off-flavors. It has been shown that reclaimed rubber and certain chemical accelerators and antioxidants used in jar rings may be important causes of off-flavors. Tests are in progress now on jar rings made entirely of natural rubber and of a combination of natural and synthetic rubber.

Processing Methods for Home Canned Fruits. (Cooperative Project with the Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture.) (W. B. Esselen, Jr., A. C. Avery, and J. E. W. McConnell.) Additional heat penetration data have been obtained on home-canned rhubarb, strawberries, sliced apples, blueberries, peaches, tomatoes, and plums. Tests were made on both pint and quart jars filled at temperatures of 80°, 140°, and 175° F. The jars were processed until internal "cold point" temperatures of 155°, 175°, 185°, and 200° had been reached. The process times thus determined averaged a little less than those recommended in most home-canning instructions. From observations and data obtained on recommended home-canning procedures for fruit, it was evident that such variable factors as intensity of heat source, variety and maturity of the fruit, and temperature and circulation of cooling air may have

a decided effect on the required process times. Allowances should be made in prescribed process times to cover these variations.

Glass-Packed Citrus Juices. (W. B. Esselen, Jr., J. E. W. McConnell, and C. R. Fellers.) Further storage tests at 35°, 50°-60°, and 70°-85° F. (room temperature), on commercially packed grapefruit juice, orange juice, and a blend of grapefruit and orange juice, in cans and in glass containers, substantiated previous observations that the ascorbic acid content is well retained after storage for one year. Juices stored at 35° and at 50°-60° for one year showed no significant change in color and flavor, while samples stored at room temperature (70°-80°) retained their original quality for six months but after that showed a marked deterioration in flavor. At room temperature the color of the glass-packed orange juice stood up quite well, but the grapefruit juice and the grapefruit-orange juice blend packed in glass containers darkened considerably after six months. From the experimental results it appears that it should be possible to place good-quality glass-packed citrus juices on the market if warehouse temperatures are maintained at 50°-60° F. or lower. Cold storage at temperatures of 35°-40° F. is not necessary.

Prevention of Darkening and Deterioration in Flavor of Citrus Juices. (J. E. W. McConnell, W. B. Esselen, Jr., C. MacCormack, A. Kaplan, and C. R. Fellers.) The addition of ascorbic acid or the storage in an inverted position of bottles sealed with plain tin coated caps favored color retention in citrus juices. The combination of both factors produced more favorable results than either alone.

Added tin in the form of stannous ions had a stabilizing effect on the color of bottled orange juice. The optimum concentration of stannous ions, as determined by accelerated storage tests, was between 100 and 200 p.p.m. Small amounts of iron (above 8 p.p.m.) accelerated darkening of the juice.

The value of various substances as antioxidants for orange juice was investigated by adding them to the juice at 0.1 percent concentration and submitting the bottled, pasteurized juice to an accelerated storage test at 125° F. Among the substances tested were *p* hydroxydiphenyl, *p* aminoacetophenone, *b*-hydroxy quinoline, orcinol, catechol, caffeic acid, glycine, ethyl and propyl gallate, and a series of quinones having oxidation-reduction potentials between +0.131 and +0.656 volts. The gallates and sodium 2.7 anthraquinonedisulfonate (oxidation-reduction potential +0.242) were the only substances tested which protected the orange juice against flavor deterioration; however, they had little or no effect on the color.

Color Measurement of Citrus Juices by Means of a Photoelectric Reflection Meter. (W. B. Esselen, Jr., M. Paparella, J. E. W. McConnell, and C. R. Fellers.) Determination of the amount of light reflected by citrus juices by means of a photoelectric reflection meter was found to provide a rapid and accurate index of the color of the juices and a good method for following color changes in the juices during storage. Correlation with visual grading was as good as or better than the correlation between visual grading and light transmission values determined on the filtered juices. This method of color determination should be especially useful in following surface discoloration.

A white reference standard may be used, but maximum sensitivity may be obtained by using a colored reference standard similar to the color of the product being examined. In following color changes of foods during storage, the band

of light giving the best correlation with visual color changes and the maximum sensitivity must be determined for each product.

Process Times for Glass-Packed Foods. (J. E. W. McConnell and W. B. Esselen, Jr.) A cooperative project with the Glass Container Manufacturers Institute, the National Canners Association (Washington, D. C., and San Francisco, Calif., laboratories), and the California State Department of Health was undertaken to compare the heating rates and sterilizing values obtained with comparable sizes of glass containers and cans under different retort and processing conditions.

Bentonite suspensions (1 and 5 percent) were used to simulate convection and conduction heating products, respectively, as this offered a stable medium which could be duplicated and used several times in succession. The third type of food product, that exhibiting a "broken curve," could not be satisfactorily represented by a bentonite suspension because the heating characteristics varied with successive runs. Investigation of bentonite suspensions which produce a "broken curve" revealed that the rate of heating has a marked effect on the type of curve obtained. Rapid heating, with its accompanying greater convection currents until close to retort temperature, when the rate of heating and convection currents markedly slow down and permit the suspension to change from a sol to a gel state, is essential in obtaining a good broken curve.

It was concluded that the longer come-up time used in glass processing and home canning can markedly affect the type of heating curve between cans and glass containers to influence this type of broken curve obtained.

The Stability of Carotene and Vitamin A in Mixed Rations and the Comparative Efficiency of These Components for Egg Production and Growth. (Cooperative project with Department of Poultry Husbandry. L. R. Parkinson and C. R. Fellers.) Controlled levels of carotene (derived from alfalfa) and vitamin A (from fish liver oils) were added to broiler rations at the start of the experiments. Periodic determinations indicated that carotene was destroyed more rapidly than vitamin A during the first two weeks of storage; but after two weeks the vitamin A decreased at a more rapid rate. At the end of 8 weeks 61.5 percent of the vitamin A remained, whereas at the 12-week interval only 37 percent of the original amount was left. The broiler ration containing the largest amount of carotene lost 36 percent of its carotene in the first 2 weeks, but at the end of 12 weeks 49 percent of the original amount still remained. The ration containing the smaller amount of carotene showed a loss of 36 percent during the first 2 weeks, but thereafter the rate of destruction was less, and at the end of 12 weeks 62.5 percent of the original amount still remained.

Superior feathering of broilers was obtained in this experiment by feeding vitamin A in the form of a carotene extract from alfalfa.

No deficiencies in fleshing were noted regardless of whether carotene from alfalfa or natural vitamin A was fed at equivalent levels.

Normal egg production was obtained at a level of 3000 International Units of vitamin A per pound of feed, whether this was natural A or carotene extract from alfalfa. There was little difference in egg production at the feeding level of 1000 International Units of natural vitamin A per pound of feed. There seems to be no advantage in feeding three times this amount for egg production alone; but to obtain good strong, healthy chicks, a higher level of vitamin A is indicated by the hatchability and viability data.

Red Squill Toxicity Studies. (L. R. Parkinson and C. R. Fellers.) In previous work in this department, it was found that the toxic properties of raw red squill were extremely variable. Many of the squills being shipped to this country were of such inferior toxicity that their use in rat control operations was impractical. The possibilities of extracting the toxic principle from these low-quality squills were investigated with the idea of making them suitable for successful rat control. A direct result of this work was the appearance of several methods of fortifying these relatively poor quality squills.

During the past year several samples of raw red squill, originating from the Mediterranean area, were tested for their toxic effect on rats. The majority of these proved to be of poor toxic value. These findings prevented the distribution to the general public of a considerable amount of poor red squill. The processors of this material will subject it to a fortification process, thereby making a highly acceptable poison for rats.

Preservation of Pheasant Meat by Canning, Freezing, and Smoking. (C. R Fellers, E. E. Anderson, and H. U. Goodell.) In cooperation with R. E. Trippensee of the Wildlife Department, experimental packs of pheasant, which were canned in glass, frozen, or smoked, proved to be highly satisfactory in palatability and appearance. In general, only slight revisions of the procedures normally employed for the handling of chicken were required.

The Composition and Nature of Apple Protein. (S. G. Davis and C. R. Fellers.) Despite the widespread use of apples in food and food products, and the numerous chemical and nutritional studies to which the fruit has been subjected, little attention has been given to the amount and composition of apple protein. The scarcity of such data may well be explained by the fact that the protein content of the apple, in common with that of most fruits, has not been considered nutritionally significant. Estimated on the basis of the alcohol-insoluble nitrogen fraction, the protein of the apple flesh (exclusive of skin and seeds) per 16 grams of nitrogen is around 0.15 percent, alcohol-insoluble nitrogen representing approximately 50 percent of the total nitrogen of samples tested.

Significant amounts of an apple protein fraction can be removed from samples of frozen tissue, thawed, and finally macerated in an alkaline buffer solution, by means of a flotation method whereby the protein is dispersed and collected in a foam. The material as collected and dried has a nitrogen content of approximately 10 percent without purification.

Amino-acid determinations, performed on both dried apple flesh and protein extracts by microbiological methods, indicate the presence of the indispensable amino acids, with the exception of tryptophane, in proportions similar to those of most common proteins.

Work is continuing on the non-indispensable amino acids and the characterization of the protein system.

The Viability of Dried Bakers Yeast. (R. E. Morse and C. R. Fellers.) A study is under way to determine the factors which influence the viability of dried yeast. There are two major phases of the work: the factors which exert their influence during the production of the yeast, and those which are exerted during storage of the finished product.

To study the important phases of yeast production, a laboratory-scale replica of a yeast-producing plant has been set up. Here the steps used in commercial production of yeast are duplicated. The steps that are being observed for their

influence on the viability of the final product are the seed yeast, the nutritive factors during yeast production, and the method of drying, including temperature and time.

The storage factors were studied after a suitable fermentmeter had been constructed which permitted the recording of gas pressure produced by a mixture of yeast, flour, and water. Dried yeast was then packed in various gas atmospheres such as carbon dioxide, nitrogen, oxygen, and air; and stored at various temperatures, including −5°, 40°, 70°, and 100°F. Various containers were also used, in order to determine the effect of light during storage. Temperature appears to be the most important factor of all. In 18 days, dried yeast stored at 100°F. was no longer suitable for baking bread, regardless of the container or the gas atmosphere used.

Vitamin D Bioassay Research. (C. R. Fellers and L. R. Parkinson.) As yet, no physical or chemical methods have been devised that are accurate for the determination of vitamin D in food. A literature survey has been made of likely procedures, and research will be carried out to check new laboratory methods against the standard rat bioassay. An enormous saving of time and cost will result if chemical or physical procedures can be perfected.

Of the 72 samples of vitamin D milk assayed during the year, two were seriously deficient and three slightly deficient in vitamin D.

Fish Investigations. (C. R. Fellers and A. Lopez-Matas.) Studies on fresh, frozen, canned, and smoked swordfish have been completed, and three scientific papers prepared for publication. The study covers both technological and nutritional aspects.

Rapid Estimation of Added Aluminum in Foods. (C. R. Fellers and R. Barton.) A nephelometric method has been perfected which is accurate for inorganic aluminum to ±10 parts per million. The brine or pickle is cleared with phosphotungstic acid, the pH adjusted, and the aluminum hydroxide precipitated with ammonia. The density of the suspended aluminum hydroxide is read in a specially constructed nephelometer. A description of the procedure is being prepared for publication.

DEPARTMENT OF HOME ECONOMICS NUTRITION

Julia O. Holmes in Charge

Losses of Iron in the Menses of Women. (A. W. Wertz, B. V. McKey, and J. O. Holmes.) Because of the loss of blood in the menses it is customary to recommend a higher level of iron for women than for men. As a part of the study on the metabolism of iron in women, conducted last year, a collection was made of the menses throughout the 115-day experimental period. Because of its significance in determining the requirement of iron by women the results of the analyses of the material are presented here. The losses of iron by these four women varied markedly, although the loss of an individual woman was fairly constant from period to period. The subjects ranged in age from 24 to 37 years; none had had any children. The range in iron excreted per menstrual period was as follows: Subject A, age 28 years, 1.98–2.49 mg.; Subject B, age 29 years, 2.6–8.13 mg.; Subject C, age 24 years, 15.13–33.9 mg.; Subject D, age 37 years,

8.04–10.98 mg. There appears to be no correlation between the age of the subject and the amount of iron excreted per period. From the limited data presented here, it appears evident that there is a wide range in the amount of dietary iron needed by different women to offset the loss of iron in the menses. For example, Subject C, losing an average of 25 mg. of iron per menstrual period and being able to utilize about one-third of her dietary iron (1946 Exp. Sta. Ann. Rept.), would probably need about 3 mg. of iron in the daily diet to offset this loss. On the other hand, Subject A, losing an average of about 2 mg. of iron per period and being able to utilize about one-third of her dietary iron (1946 Exp. Sta. Ann. Rept.), would need only 0.5 mg. iron in her daily diet to offset this loss.

Iron Content of Milk. (A. W. Wertz, B. V. McKey, and J. O. Holmes.) Although it has long been appreciated that milk is a poor source of iron, the values in the literature range from 0.114 to 1.4 mg. per liter. Over a period of 115 days, milk was obtained from the Dairy Industry Department of the University and analyzed for iron. Six quarts were obtained daily and well mixed; aliquots from the mixture were taken and pooled for five consecutive days. Iron determinations were made on 23 pooled samples. The organic matter in the milk was destroyed by wet ashing with nitric and sulfuric acids. O-phenanthroline was the color reagent used for formation of the colored complex, the intensity of which was measured in a Beckmann spectrophotometer. The amount of iron present was calculated from a calibration curve. Because of the large amount of calcium present in the milk, a heavy white precipitate was formed after digestion which necessitated filtering. In order to determine whether any iron was lost throughout the procedure because of the formation of insoluble iron salts, etc., the following procedure was used for several determinations as a check on the method. Six 100 ml. aliquots of milk were measured into 500 ml. erlenmeyer flasks. To three of the flasks containing milk a known quantity of iron was added. The contents of these six flasks, 3 control flasks containing only the standard iron solution and 3 control flasks containing only the reagents used, were carried through the entire procedures of evaporation, digestion, filtration, development of color, and measurement in the spectrophotometer. The data obtained on 8 different series show that recovery of the added iron was 100.05 percent. These results indicate that the wet digestion method of ashing and the use of O-phenanthroline as the color reagent is suitable for the determination of iron in milk. The average value for 23 samples of milk covering a period from January through May was 0.30 mg. iron per liter with a range from 0.25 to 0.38 mg. per liter. The lowest values—0.25–0.29 mg. per liter, were consistently obtained during March and April.

The Excretion of Iron by the Kidney. (B. V. McKey, D. C. Staples, J. O. Holmes, and A. W. Wertz.) It has long been known that the quantity of iron in the kidney secretion is small. At the time when the study on iron utilization by women was being planned, the question arose as to whether or not the urinary iron had to be determined. This question was of great importance not only for its significance in the experiment, but also from the standpoint of the work involved in the determination. Therefore, a survey of the studies reported in the literature since 1880 was made. The range in the urinary iron values reported by various laboratories was found to be great; e.g., some workers reported urinary excretions as high as 1 mg. iron per day and one laboratory reported iron excretion by one individual which ranged from 0.01 to 1.93 mg. per day and averaged 0.24 mg. These high values, as well as the great variability in values, indicated

that a careful study of urinary iron would be expedient, particularly since a diet very low in iron was to be fed. During the first 50 days of the experiment when the subjects ate 3.75 mg. iron daily, the daily iron content of the urine for subjects B, D, E, and G was 0.041 ±0.011, 0.045 ±0.012, 0.059 ±0.019 and 0.062 ±0.019 mg. respectively. In terms of percentage of the quantity of iron eaten these values for urinary iron represent only 1.1, 1.2, 1.6 and 1.6 percent. During a subsequent 35-day period in which the iron intake was increased to 5.8 mg. daily, the urinary excretion of iron did not rise; on a percentage basis, the values were, therefore, lower; namely, 0.6, 0.6, 0.4 and 0.9 percent. No correlation was found between the daily volume of urine excreted and the daily urinary iron. From the data obtained, it is evident that even on extremely low dietary levels of iron, it is not necessary to determine the iron content of the urine.

Tooth Decay Studies: Sucrose, Glucose and Lactose as Cariogenic Agents. (Julia O. Holmes, L. R. Parkinson, Lois Brow, and Anne W. Wertz.) As a result of last year's findings that dental caries could be induced in the *Norwegian* albino rat by feeding sugar as the sole source of carbohydrate in an adequate diet, this year other types of sugars have been fed. The sugars selected were those that form the major portion of man's sugar consumption: namely, sucrose as found in cane and beet sugar, dextrose which occurs in fruits and corn syrup, and lactose, the sugar of milk. These sugars were fed to numerous groups of rats over a period of two years as the only source of carbohydrate in "synthetic" diets which contained all *known* nutrients. Although the rats grew well and were in good health, they developed tooth decay, irrespective of the type of sugar fed. These results showing the cariogenic properties of sucrose and glucose are in accord with the findings of the Wisconsin investigators who have reported that the *cotton* rat will develop tooth decay if fed excessive amounts of fermentable carbohydrates. The National Health Institute reported in 1945 that they had induced caries in about 30 percent of one group of *Norwegian* rats fed sucrose; but that in subsequent groups fed glucose or sucrose, either commercial or confectioners grade, caries did not occur. In respect to lactose, no other report has been found in the literature indicating that it, too, is a cariogenic agent. Since lactose does not undergo fermentation as do the other mono- and di-saccharides, it is obvious that the tooth decay-inducing properties of a sugar are not dependent upon the fermentability of that sugar. It is also obvious that if milk contains some substance which protects against tooth decay, as has been reported by the Wisconsin investigators, that substance is not the milk sugar, lactose.

Tooth Decay Studies: Excessive Use of Sugars Not Sole Cause of Tooth Decay. (Julia O. Holmes, L. R. Parkinson, and Lois Brow.) Although the feeding of sugars to rats as their sole source of carbohydrate has resulted in the early development of tooth decay, tooth decay has been experimentally produced this year in rats that had never been fed sugar. The finding that other types of carbohydrates as well as glucose and sucrose would permit the development of tooth decay, is in direct contradiction to the results of other investigators who have asserted that caries does not develop in diets in which sugar is replaced by starch or dextrin. The first indication that a sugar-free diet is conducive to tooth decay came as a result of an attempt to construct a "synthetic" diet which would have some of the essential features of the "corn-meal" diet used by many laboratories for the development of caries in animals. Since the corn-meal diet is notable for its high content of raw starch and its relatively low content of protein, a diet containing starch as its sole carbohydrate and 15 percent of the milk protein, casein,

was constructed. It contained all the *known* ingredients necessary for good growth. The observation that some of the rats fed this ration had cavities on the grinding surfaces of their teeth came as a distinct surprise. As a result of these findings many rats have been reared on diets containing raw or cooked corn starch as their sole source of carbohydrate. Caries has been found in all groups fed such rations. Experiments are now in progress to determine the conditions under which tooth decay will result in the presence of starch. It is felt that research on diets containing raw or cooked starches provides a promising line of investigation since few human beings consume diets in which the major portion of their carbohydrate is sugar.

Tooth Decay Studies: Raw Corn Contains a Caries-Inducing Factor. (Julia O. Holmes, L. R. Parkinson, Anne Wertz, and Lois Brow.) A "corn-meal" diet is used in most laboratories today to produce tooth decay in experimental animals. This diet is composed of 66 parts of coarsely ground whole corn, 30 of whole-milk powder, 3 of dried alfalfa meal, and 1 of pure table salt. Since this diet is notorious for the rampant caries it produces, it was decided to feed various fractions of corn to determine whether or not a fraction could be found which had cariogenic properties. The corn fractions were obtained from the Corn Products Refining Company, Argo, Illinois. They included a crude corn oil obtained from the corn germ: corn steepwater, which contained the major part of the water-soluble minerals and vitamins of the kernel; zein, one of the corn proteins; and a gluten fraction which contained, in addition to the corn gluten, zein and some of the corn xanthophyls, and which assayed about 50 percent protein. To the basal ration into which these fractions were incorporated, corn starch and 15 percent casein were added as the sole carbohydrate and protein. The rations were ground to the fineness of flour. The rats receiving corn steepwater developed no more tooth decay than did their brothers and sisters receiving the basal diet only. In contrast those receiving gluten, zein, and crude corn oil had twice as many sites of decay as did their controls on the basal diet. This is the first demonstration of the presence, in a food, of an agent which accelerates the decay of teeth. The findings suggest that, if sugar is a cariogenic agent, it may be only one of many. One of the plans for the immediate future is to determine the nature of the cariogenic factor in corn.

DEPARTMENT OF HORTICULTURE

R. A. Van Meter in Charge

Control of Weeds in the Nursery by Chemical Sprays. (C. H. Gilgut, Waltham.) Of the chemical weed killers in common use at present, the industrial solvent Savasol No. 5 shows most promise for control of weeds in the nursery. It was extensively tested in 1946 in the Field Station nursery and in nearby commercial nurseries. As a result, a number of the more progressive nurseries are using this weedicide in their weed control program. The oil is used undiluted.

So far, the best method of applying the oil is with a hand operated tank sprayer equipped with a nozzle that gives a flat fan-shaped spray. This gives good control of the spray and permits wetting weeds close to a plant without wetting the plant enough to injure it.

Spraying small weeds is more effective and cheaper than spraying large weeds. The small weeds are killed more quickly; there is less risk of injury to the plants since the spray is kept close to the ground; less material is used; and it takes less time to spray a given area.

Late fall spraying of grass weeds which winter over reduces the number of such weeds in the spring.

To the list of narrow-leaved evergreens which are highly tolerant can be added mugho pine. Less tolerant is the Greek juniper, *Juniperus excelsa stricta*.

Study of Herbaceous Perennial Material. (C. J. Gilgut, Waltham.) Fifty varieties of plants in the perennial test gardens did not survive the winter. Of these, sixteen were so-called "hardy chrysanthemums," and it is increasingly evident that most chrysanthemums are not reliably hardy here when not protected by mulch or wintered in a cold frame.

Few replacements have been made and no new plants acquired because the gardens are to be moved to another location to make way for the new laboratory and administration building. The preparation of the new location—clearing, grading, laying out of beds, and seeding of walks—is slowly being finished and it is hoped that by fall many of the plants will have been moved in from the old garden.

The collection of American and English hybrid delphinium—among them Gold Medal Hybrids, the color series of Giant Pacific hybrids, Wrexham hybrids, and Blackmore and Langdon hybrids—made good growth and an excellent display in the spring. The Giant Pacific hybrids were awarded the L. H. Leonian Memorial Cup for excellence by the American Delphinium Society, and a cultural certificate and silver medal by the Massachusetts Horticultural Society.

The phlox collection of varieties in commerce is not yet complete, but it is apparent that some are not true to name and several are being sold under different names.

Factors influencing the Rapidity of Growth of Nursery Stock. (C. J. Gilgut, Waltham.)

Rhododendron Leaf Bud Cuttings. Leaf bud cuttings of 30 named varieties of hybrid rhododendrons taken in November, and again in February, treated with the more common root-inducing substances in liquid and powder form, and placed in various propagating media in the greenhouse failed to root. A few were still alive in June.

Effect of pH and Nitrogen, Phosphorus, and Potash on Growth of Yews. It is a common belief among some nurserymen that yews grow better at a pH above 5.8. When the pH of unfertilized field soil was adjusted at pH 4.5, 5.0, and 7.0, there was no appreciable difference in the growth of rooted cuttings of *Taxus media hicksi* and *Taxus cuspidata nana* during the first season.

These varieties grew equally well in unfertilized field soil and in field soil treated so that (1) the nitrogen, the phosphorus, or the potash was high; (2) the nitrogen and phosphorus, the nitrogen and potash, or the phosphorus and potash were high or (3) the nitrogen, phosphorus, and potash were high.

DEPARTMENT OF OLERICULTURE

G. B. Snyder in Charge

Asparagus Investigations. (Robert E. Young, Waltham.) The second generation asparagus planting has been cut now for seven full years and has about reached the half-way point of economic production. The third cutting season produced the greatest yield. The yield for 1945 was only 51 percent of this 1942 yield, and the 1946 crop although greatly improved was still only 71 percent of the highest yield.

An examination of the yield data indicates a decided tendency toward biennial bearing not unlike that found in apples. While only seven years records are available for study, there always have been alternate high and low yields; never two successive increases or decreases. Attempts to correlate this rise and fall of yields with rainfall have been unsuccessful, and there is only a slight relationship to spring temperatures. As might be expected the highest producing strains show the greatest variation in yield from season to season.

This second generation of plants has spread out so far in the rows that it is no longer possible to obtain accurate individual plant records as previously. Of the plants whose accumulative yield places them in the top 50 (12 percent), only four have been in this category all seven years. This also demonstrates the extreme variation in production of asparagus plants. The male asparagus plant is considered the better producer and 72 percent of the plants in the top 50 are males.

In 1942 plants which had started to produce high yields were chosen as parents for the third generation. It is interesting to note that of ten so chosen nine remain in the top 50. A study of the yield records shows that very few plants which produced well at the start have dropped, while there are some which started poorly that are now yielding well.

The highest yielding plant in the experiment is No. 4-79 which produced an average of 2.6 pounds of asparagus per year as compared to the annual average of 0.88 pounds per year for all the plants.

To determine whether the high yielding plants can transmit this characteristic to the next generation, a third planting was made using various combinations of male and female plants previously described. This planting has been set for two years, and the count of the summer stalks in 1946 followed the same pattern as in 1945, with the most vigorous plants producing twice as many stalks as the commercial varieties.

Forty-six plants died during the second year which, with the 19 that died the first year, makes a total of 63 out of 1900. Of those that died in 1946, half had shown no weakness the previous year, which brings up the question of winter-killing. There are five strains that still have a perfect stand and none of the strains have lost over 5 percent; while the two commercial varieties have lost 11 and 13 percent. These plants did not die because the crowns planted were too small, since there was no significant difference between the weight of the crowns of the plants that lived and those that died. The data appear to indicate that it is possible to breed a hardy strain of asparagus. Loss of plants after an asparagus planting has been established is one of the reasons for low yields and the low economic returns from this crop.

Vegetable Breeding for Improvement of Quality. (Robert E. Young, Waltham.) During the year breeding work has been conducted with broccoli, greenhouse cucumber, celery, rutabaga, New York type lettuce, tomato, carrot,

and Butternut squash. While progress has been made in the development of strains of celery, rutabaga, and greenhouse cucumber better adapted for local use, it is insufficient to justify detailed discussion.

Broccoli. The 1946 fall broccoli plots came into production during unseasonably warm weather with the result that many varieties and strains failed to make a marketable head. Under these conditions, a fall type, tentatively called Strain 29, was outstanding. This strain is a slow-growing type which requires so much time to produce the head that short periods of unseasonable weather have little effect on it. It was tried in the spring and found worthless. Seed has been produced for expanded fall trials and further purification.

The spring trials in 1947 showed the two strains recently developed for this season, namely Waltham No. 7 and No. 11, to be outstanding producers as an early crop. They also gave total yields considerably higher than that of the best commercial variety. The commercial variety which was best in early yield was only average when the total yields were considered; and the variety that ranked next to Nos. 7 and 11 for total yield was only 75 percent as productive in the early season.

Thus, it would seem that we have been able to retain characteristics for good early yield with the necessary vigor that makes for large total yields. Tests with growers indicate that strains No. 7 and 11 have real value, but they require a little more selection for uniformity.

Carrot Seed Production. The maintenance of a supply of stock seed of the Field Station strain of Hutchinson carrot has always been a part of the Carrot Breeding Project. To produce this seed, which is supplied to the carrot seed growers, a fall crop was grown and selected roots placed in a storage pit. In the spring these were re-selected for shape and external color, and internal color was observed by cutting off the bottom third of the root. Then the roots were planted in the field in early spring. By that method there was a small amount of crossing with wild carrot, and the resulting hybrids were sometimes overlooked in the seed fields in the west. This accounted for the presence of a small percentage of white, yellow, and poor-shaped roots found in the local carrot fields.

A method has now been developed whereby this seed is grown in the greenhouse with bees used as pollinators, and it is mature before the wild carrot blooms. By this procedure the off-color carrots were reduced from 2 percent in field-grown stock to none in the greenhouse crop. It is planned to supply seed producers an ounce or so of this elite stock seed, and they in turn can multiply the seed in California where wild carrots are not a problem.

The breeding of a better carrot continues, but last season work was considerably handicapped by the presence of an unusually high percentage of aster yellows which destroyed some of the best breeding lines.

New York Type Lettuce. The testing of Waltham Imperial Lettuce on a sufficient scale to really determine its place has been delayed by lack of seed. The seed crops, both local and that grown in California, have been disappointing.

In the 1947 crop in which early plants were set in the field, Waltham Imperial showed much more uniformity of plants and in maturity than did Great Lakes. At the time of the first cutting Great Lakes produced 55 percent marketable heads while Waltham Imperial produced 70 percent.

While Great Lakes, Waltham Imperial, and several other new strains of similar type, have about taken care of the requirements for a late set lettuce, there

remains a definite need for a first early type. Several lines are now being purified with this in mind. Even with Great Lakes, growers located away from the cooling effect of the seashore have had trouble with the lettuce crop seeded in the field due to scald, breakdown, and slime in the heads, brought on by hot weather at heading time. The experimental plantings were so affected this year, and almost 100 percent of the Great Lakes type plants which have an unprotected head were unmarketable because of breakdown. The only plants not affected were those of the so-called crinkle type which have leaves that are savoyed, and also have more protection from leaves on top of the head. A seed crop of this type of plant is being produced for more extensive trials next year.

Trellis Tomatoes. The work and publications of plant breeders, and the offerings of commercial seedsmen of hybrid tomato seed, have created an interest among local market gardeners. Because of market customs and preference, the type of tomatoes produced elsewhere cannot be used locally by commercial growers. To determine whether there is sufficient advantage to warrant the higher cost, five different tomato hybrids were planted. Several combinations of strains and varieties were used in a search for the best hybrid.

The early yield of the five different hybrids, all of which had as one parent either Trellis No. 22 or Waltham Forcing, was 25 percent greater than that of either of these two, which are the standard by which the hybrids must be measured. The advantage at the three-quarter harvest period had shrunk to 16 percent, and it was only 10 percent for the complete harvest.

Since the greatest returns are for early tomatoes, a difference of approximately 1 pound more per plant from the hybrids at this stage would seem to more than justify the expenditure of 1 cent per plant, which is one current quotation for hybrid tomato seed.

The fruit from some hybrids was too soft; from others too small. Considerable more testing will be required to find the best combination.

A hybrid between determinate varieties, such as Red Cloud and Victor which are very early, and Trellis No. 22, when grown by the flat culture method, produced a sufficient increase in yield to offer promise for the future for those growers who do not trellis tomatoes.

Progress is also being made in testing Selections No. 1 and 3 by growers. Selection No. 3, which has been named Waltham Scarlet, shows promise for the home garden, and will be so featured by a Boston seed firm.

Butternut Squash. Progress has been made towards the breeding of a strain of high-yielding Butternut squash with a minimum of crooked, cracked, and too long fruits. Inbred lines were grown during the year that produced no fruit which was too long. That same strain also had no crooked fruit. An analysis of the percentages of the various grades produced by the inbred lines shows that, if too much reduction in the length of fruit is made, an increase occurs in the percentage of culls, i.e., fruit less than 7 inches or weighing less than a pound.

The occurrence of cracks in the fruit seems to be associated with moisture supply. Cracking takes place during and after rains that break long dry periods. The tendency to crack seems to be at least partially genetic as some lines had only 5.8 percent cracked fruit while others had as much as 27 percent. There does not seem to be any association between cracking and any other grade defect, such as large or crooked fruit.

In storage experiments of an exploratory nature to determine the conditions under which to test the inbred lines for keeping qualities, loss in weight of But-

ternut squash was 29 percent at the end of 14 weeks. The greatest loss occurred in the first two weeks. Dipping the squash in a wax emulsion at harvest or two weeks later reduced the loss to 17.5 percent. Squash placed in a refrigerator at 35° F. showed very little loss in weight and kept for three to four weeks, but rot was general and complete at the end of six weeks. Other low-temperature conditions will be tested in an effort to find a means of cutting the loss on Butternut squash intended for short storage.

Weed Control in Vegetable Crops. (William H. Lachman.) The use of Stoddard Solvent as a weed killer in fields of carrots and parsnips has increased greatly during the past year. A survey made during 1946 revealed that about 1000 acres were kept free of weeds by this method in Massachusetts alone.

Briefly, the method consists of spraying undiluted Stoddard Solvent on weedy carrot fields at the rate of 100 gallons per acre when the carrot plants have developed one to four true leaves and while the weeds are small; that is, not more than two inches tall. Best results are obtained when the oil is applied with a nozzle that delivers a flat-fan spray at 75 to 100 pounds pressure. Hand weeding has been eliminated except where ragweed is prevalent. For some unexplained reason, ragweed is not killed along with the other weeds.

Susceptible plants are killed very rapidly. They begin to wilt a few minutes after spraying and are dead within two or three days. The spraying usually results in a slight over-all bleaching effect on the green color in the carrot plants. This does not appear to be associated with any damage to the plants, and the darker color that is characteristic of unsprayed plants usually returns within ten days.

Sometimes one or more of the older leaves in the outermost whorl of young carrot plants were rather seriously scorched or burned as a result of spraying with Stoddard Solvent. It has been rather definitely established that this damage was most apt to occur after the plants had been sprayed while wet from a rain or heavy dew. Repeated tests indicated that the yields of sprayed carrots were not affected adversely, and there was no apparent differential susceptibility among sixteen varieties and strains that had been sprayed three times with oil.

Consumers often complain that California-grown carrots taste of oil, but we have had no rejections of sales nor adverse comment from 1500 acres grown and sprayed with oil in Massachusetts during the past two years.

Of the various Umbelliferous crops tested, carrots displayed the greatest resistance to damage from Stoddard Solvent, but even carrots are damaged when sprayed after the roots attain a diameter of ¼ to ½ inches. When sprayed after this stage the oil often destroys the heart of the plant and may envelop the core of the root. Parsnips were sprayed with relatively little injury up to the 4-leaf stage, but they were badly injured when sprayed in later stages of development.

Small celery seedlings grown out-of-doors were resistant to Stoddard Solvent but were damaged beyond recovery when sprayed after the 2-leaf seedling stage. Parsley, fennel, caraway, coriander, dill, celeriac, and parsnip-rooted parsley were also resistant to the oil in their early growth stages.

Injury to the growing point of various Umbels from Stoddard Solvent seems to be associated with the development of the characteristic hollow or groove on the top side of the petiole which directs the flow of oil down to the growing point of the plants where the rate of evaporation is low, and here the oil damage is at the maximum.

Stoddard Solvent killed such crops as beets, spinach, beans, corn, cabbage, lettuce, and onions, except where it was applied to the ground before the plumules

of these crops emerged. A number of chemicals showed promise as pre-emergence sprays on these crops.

The new hormone weed killer, 2, 4-D, was most damaging to all vegetable crops except corn. When applied just after the corn was planted, 2, 4-D controlled grassy and broad-leaved weeds without appreciable damage to the corn. When applied after the weeds had started growing, 2, 4-D killed only broad-leaved weeds.

Breeding Sweet Corn, Peppers, and Field Tomatoes for Massachusetts. (William H. Lachman.)

Sweet Corn. Considerable attention has been paid to the selection of especially early types of sweet corn as well as those that exhibit good flavor and tenderness of pericarp. Several thousand plants were self-pollinated during the year to stabilize the various factors sought within the strains. Several hundred hybrids that were produced from inbreds of this station as well as from several other experiment stations have been tested and compared with existent commercial types.

One of the most outstanding of these hybrids resulted from a cross between Connecticut 27, an inbred out of Whipples Yellow, and Massachusetts 32, an early type of Purdue 39. This hybrid is midseason in maturity and the plants produce an excellent yield of large attractive ears.

Another hybrid which is especially noteworthy resulted from crossing Connecticut 3 with Massachusetts 2410-191. For two years this hybrid has matured earlier than any other variety in our trials. The seed is being increased for test on a large scale.

Considerable attention has been paid to an unusual type of corn called supersugary. Several strains of this type are approaching uniformity and should provide very sweet types of corn.

An interchange of breeding material among members of the Northeastern Corn Breeding conference has made a great deal of valuable material available for further breeding work. Several of the strains obtained in this manner combine very well with some of our inbreds, but further testing is necessary before this material can be made available for distribution.

Peppers. Further selection work has isolated a number of promising strains of peppers but they are not yet sufficiently uniform to send out for trial. One of these is of the Worldbeater type and has very attractive fruit with thick flesh. This appears to be resistant to certain strains of tobacco mosaic. Another strain resembles the variety Merrimac Wonder very much and it is also resistant to some strains of tobacco mosaic. Definite progress is being made in developing strains that are mosaic resistant.

Tomatoes. A large number of advanced generation selections from crosses among such varieties as Bounty, Earliana, Pennheart, Valiant, Bestal, and Firesteel have been carried along for several years. Very little work has been accomplished during the year because of a most severe infestation of late blight. It was clear that none of the selections exhibited any resistance to this disease. A few early fruits escaped the disease to allow for one more generation of selection. Several F_1 hybrids were included in the variety trials and a few of these were rather outstanding in yielding ability. Of the hybrids under test, Fordhook Hybrid, performed especially well during the early part of the season.

The Culture and Nutrition of Vegetables. (W. H. Lachman.)

1. Tomato plants grown in plots mulched with manure did not succumb to foliage diseases (particularly late blight) as badly as those mulched with straw or those grown without mulch. Sugar cane fibre used as a mulch continued to have a marked depressing effect on the growth and yield of tomato plants.

2. Red Cloud and Pennheart produced more early fruit than any other tomato varieties in this year's trials. Cracking of fruit has been the most important factor in lowering the grade of out-door tomatoes. A rather late variety named Crack-Proof was practically free from cracking this year.

3. The variety Fordhook 242 lima bean outyielded all other varieties in our trials. This variety has consistently performed well in our plots.

4. The use of a plant hormone applied as a spray significantly increased the set of greenhouse tomatoes. About 50 percent of the fruits were seedless and many had objectionable air pockets where one would ordinarily expect to find pulp.

5. Carotene analyses of carrots continue to indicate wide differences among the varieties. Morse's Bunching and Imperator are among the highest in carotene content. Roots of all varieties increased in carotene as the growing season advanced, and roots stored for five months contained appreciably higher amounts of carotene on a fresh weight basis than when they were placed in storage.

DEPARTMENT OF POMOLOGY

R. A. Van Meter in Charge

The Influence of Various Clonal Rootstocks on Apple Varieties. (J. K. Shaw and W. D. Weeks.) For the fourth successive year there was frost damage in the large stock-scion orchard. It requires many years to determine the value of these stocks for the many varieties in cultivation. At present we believe that Malling I and II are the most desirable for commercial orchards where the grower desires trees not so tall as ordinary seedling-rooted trees. They stand winds nearly as well as seedling-rooted trees, require a little less space, begin to bear younger, and give larger acre yields. Malling VII is promising but we have not had as much experience with it. It is believed that Malling XVI is superior, at least for McIntosh, but it dwarfs the trees little or not at all. Trees on Malling IX are excellent for home gardens but many require support. They are not recommended for commercial orchards.

The question of varietal adaptation is complicated and requires further study. In general, the best varieties for dwarf and semi-dwarf trees are those that make moderately vigorous growth. The very vigorous ones, such as Gravenstein and Baldwin, tend to overgrow the stock; and the weaker ones, like Duchess and Wagener, do not begin to bear much earlier than they do on seedling roots. Northern Spy and Yellow Delicious are among the best varieties to grow on dwarfing roots.

Two papers were published in Volume 48 of the *Proceedings of the American Society for Horticultural Science.*

Lethal Incompatibilities Between Clonal Stocks and Varieties of Apples. (J. K. Shaw and W. D. Weeks.) It was reported last year that buds from shoots of the normal strain G which had grown in the top of a tree of the lethal strain

R were still alive. Later in the summer all the trees of this hitherto normal strain died in typical fashion. This seems to prove that the lethal factor in strain R had passed into strain G and indicates that the lethal factor is of a virus nature. If this is true, no vector is present in our nursery, or the virus can be transmitted only by actually transferring virus tissue to a healthy tree. This is the first indication we have observed that a healthy tree can acquire the lethal factor.

The observation that Blaxtayman budded on Spy 227 grows vigorously the first year and then dies has been confirmed. Trees of several lethal strains were budded on Spy 227 interstock, on Spy 227-2 and on Spy 227-12. Those with Spy 227-12 roots grew much better than those on Spy 227-2 roots.

Tree Characters of Fruit Varieties. (J. K. Shaw, A. P. French, O. C. Roberts, and W. D. Weeks.) The examination of fruit-tree nurseries for trueness-to-name, which began in 1921, still continues. This inspection was extended to Tennessee and Alabama last year and in 1947 will extend to Iowa and Kansas, and include about 30 different nurseries. Although many of these nurseries have been examined annually for many years and the misnamed trees eliminated, still new mixtures appear. But these are detected at once, which practically prevents propagation and distribution to growers. New varieties appear and must be studied; thus this project is one that has no end.

Effect of Orchard Mulches on the Plant Nutrients in the Soil. (J. K. Shaw and W. D. Weeks, in cooperation with the Chemistry Department.) This project has been interfered with by the war. Soil samples were taken this year and the hay mulch applied. The trees with hay mulch look the best and the unmulched trees the poorest. Further comments on this project may be found in the Report of the Chemistry Department.

The Nature of Winter Hardiness in the Raspberry. (J. S. Bailey, A. P. French, and R. A. Van Meter.) It seemed possible that there might be a relationship between the rest period of raspberries and the amount of cold the plants will stand in winter; therefore, a study of the rest period was started three years ago. Each fall during November and December raspberry canes of six varieties were brought into the greenhouse at regular intervals and the time necessary to force the buds into growth was determined. From this work the following conclusions can be drawn: (1) The deepest rest, when the buds are hardest to start, is reached about November 1. (2) The time at which the deepest rest is reached is dependent on both the variety and the season, but the season is the more important factor. (3) The buds come out of the rest gradually, the rate depending mostly on the variety and to a lesser degree on the season. (4) The time the buds are through the rest period depends largely on the time they went into the rest and hence on the season. It depends to a lesser extent on the variety. (5) Those varieties which are most resistant to winter cold are usually the slowest to come out of the rest period. This suggests a relationship between rest period and cold resistance. Varieties which are least irritable, that is, are least apt to be started into growth during warm periods in the winter, are most cold resistant.

Blueberry Culture. (J. S. Bailey.) The attempt to control mummy berry by spraying with Fermate was continued in 1946. Some bushes received six, some seven, some eight, and some nine sprays. Primary infection of shoots and blossom clusters was much lighter than in 1945. There were also fewer mummied berries on the unsprayed bushes than in 1945. Although the differences among

the various numbers of sprays were too small to be significant, the spraying definitely reduced the number of mummies. This work is being continued.

In the experimental plantings there are a number of bushes infected with blueberry stunt, a virus disease. These are being kept to watch the progress of the disease. As yet, there has been no evidence of any spread from diseased to adjacent healthy bushes. However, the progress of the disease in an infected bush is much more rapid than had been anticipated. So far diseased bushes have been found in only two varieties, Cabot and Concord. Since the symptoms differ in each variety, buds from diseased bushes were set in healthy bushes of several other varieties so that the symptoms might be studied as they developed.

An infestation of a Lecanium scale had been slowly building up, particularly on the variety Concord. Previous attempts to control it had been only partially successful. In the spring of 1947 delayed dormant sprays of DDT emulsion, D-542, and "Peninsula Oil" were applied in cooperation with the Entomology Department. The DDT emulsion had little effect, "Peninsula Oil" killed most of the scale, and D-542 eliminated them almost completely.

Nutrition of the High-Bush Blueberry, Especially in Relation to Soil Reaction. (J. S. Bailey.) For many years it was believed that manure would kill cultivated blueberry bushes. A comparison of horse, poultry, and cow manure over a period of five years has shown that (1) the bushes will thrive where as much as 20 tons of horse manure per acre are applied, and (2) there is no significant difference among manures when they are used in such quantities as to give about the same amount of nitrogen per acre. This phase of the work has been concluded.

In the summer of 1946, leaf symptoms of what appeared to be magnesium deficiency were observed on a few blueberry plants. Chemical analyses of the leaves of several bushes revealed that they contained only 0.14 percent magnesium or less. With the apple, 0.20 percent is considered the danger line. When the analysis gets that low, an effort should be made to get more magnesium into the tree. This situation in blueberries is being studied further.

Magnesium Deficiency in Massachusetts Apple Orchards. (J. K. Shaw and W. D. Weeks.) The leaf scorch typical of this deficiency has been little in evidence during the past three years. This is not saying that magnesium deficiency is no longer present. Probably it may interfere with best growth and fruitfulness and still no serious leaf scorch be present. Moderate to heavy applications of Epsom salts were applied to a large number of trees and leaf samples from 110 trees collected for analysis. The analytical work is not yet completed, but so far there is little indication of success in getting magnesium into these mature apple trees. The recommended measures to alleviate magnesium deficiency are still 20 pounds of Epsom salts in 100 gallons of the regular spray solution applied in three or four of the earlier foliage sprays for immediate results, and dolomitic limestone, 1 to 2 tons per acre, for more lasting results.

Thinning Apples with Sprays. (W. D. Weeks.) Because of a light bloom in most of the Station orchards and injury to blossoms from spring frosts, extensive trials to thin apples with sprays were not attempted in 1947. However, some results were obtained with a commercial preparation of naphthalene acetic acid, 20 p.p.m. Early McIntosh, Golden Delicious, Red Astrachan, Wealthy, and Lobo were thinned quite effectively; while Kendall, Melba, Blackmack and Richared were thinned excessively. Considerable dwarfing and distortion of the

leaves was caused by the naphthalene acetic acid on Wealthy, Early McIntosh, and Melba; while Golden Delicious, Richared, Blackmack, Red Astrachan, Kendall, and Lobo varied from no apparent injury to moderate injury.

Limited trials were also made with a new thinning mixture which the Delaware Station reported as showing much promise. The mixture consisted of polyethylene polysulfide (Goodrite p.e.p.s.) and a complex product of zinc dimethyl dithiocarbamate "Zimate" with cyclohexylamine. It was used at the rate of 2 pounds of Goodrite and 1/8, 1/4, and 1/2 pound of the "Zimate" complex per 100 gallons. Applications were made on single branches of several varieties at one and two weeks past full bloom. Under the conditions of the test none of the sprayed branches showed a significant reduction in set over the checks.

Chemical Control of Poison Ivy and Other Weeds. (J. S. Bailey.) Poison ivy is often a serious pest in orchards where it grows under fruit trees, often in rank profusion. Workers are sometimes seriously poisoned when picking up dropped fruit at harvest time or when working in the orchard at other times. During 1946, several materials were used as sprays in an attempt to kill this pest. Four formulations of the new weed killer, 2, 4-D, were tried. Two of these were esters, one a butyl and the other a methyl ester. Both of these were tried at the usual strength of 1,000 p.p.m. and at 2,000 p.p.m. None of the four formulations was effective. Mixtures of several different concentrations of ammonium thiocyanate with tar acid oil and kerosene were tried. These killed only the tops and new tops developed from the old roots. A proprietary mixture of sodium chlorate and a deflagration agent was also tried, used at 1 pound per gallon of water. This was more effective than the 2, 4-D sprays but eradication was not complete. As in 1945, ammonium sulfamate proved to be the most effective eradicant for poison ivy. At ¾ pound per gallon it was 90 percent effective, and at 1 pound per gallon it was almost 100 percent effective.

American bamboo (*Polygonum Seiboldii* De Vriese) is one of the most persistent and fast growing weeds imaginable. It is not a common weed, but where it has become established, it can take over large areas in a short time. Two ester formulations of 2,4-D at single and double strength were tried, without effect other than a little twisting of the tender tips. Two applications of ammonium sulfamate at 1 pound per gallon, the first June 26 and the second August 8, failed to kill this pest.

Ammonium sulfamate is very toxic to peaches and cultivated blueberries but harmless to apple trees four years old or older when sprayed on weeds under them. Its effect on four-year-old pear, plum, and cherry trees was tested by applying the spray on the weeds around them at 1 pound per gallon, 1 gallon per 100 square feet. One spray was applied June 25 and a second September 6. No visible effects have been observed on the trees; so that material appears to be safe for use around cherries, plums, and pears, at least after they are four years old.

A proprietary mixture of sodium chlorate and a deflagration agent was also found to be safe around four-year-old cherries, plums, and pears when used at 1 pound per gallon, 1 gallon per 100 square feet. This mixture is toxic to cultivated blueberries.

Witch grass, sometimes called quack grass or twitch grass, is often a problem around young trees in an orchard. Previous experience indicated that fall applications of ammonium sulfamate were more effective than summer applications. A series of plots was laid out in the summer of 1946 to test the effectiveness of ammonium sulfamate and a proprietary mixture of sodium chlorate at different

times, at different concentrations, and at different rates of application. It was found that ammonium sulfamate at ¾ pound per gallon or the chlorate mixture at 1¼ pounds per gallon, used at the rate of 1 gallon per 100 square feet, did a 95 to 100 percent job of killing the witch grass. In the summer of 1947 it was observed that the witch grass came back into the plots from around the edges faster in the ammonium sulfamate plots than in the chlorate mixture plots.

A butyl and a methyl ester formulation of 2,4-D were tried on chokecherry at 1,000 p.p.m. and at 2,000 p.p.m. in August, 1946. The materials were equally effective, and single was as good as double strength. Growth of the treated bushes was very weak and very abnormal in 1947. Leaves were very narrow, curled, very sharply serrated, and mottled. Fruiting stems made an abnormally vigorous growth but died without producing fruit.

DEPARTMENT OF POULTRY HUSBANDRY

F. P. Jeffrey in Charge

Broodiness in Poultry. (F. A. Hays and Ruby Sanborn.) Selective breeding has not been successful in entirely eliminating the broody instinct in Rhode Island Reds. A limited life span particularly in males, no manifestation of the character in males, and incomplete progeny testing because of deferred broodiness offer many difficulties. The fact has been clearly demonstrated that broodiness depends upon two dominant complementary genes and that quantitative factors affecting the degree of broodiness are in operation. There is a definite linkage between broody genes and intensity of laying, and clucking without cessation of laying has been shown to indicate broody inheritance. Females should be tested for at least three laying years to discover their phenotype for the broody instinct. The last generation to complete its first laying year exhibited no broodiness in the daughters of one 36-month-old sire; but the other sire, 24 months old, gave one broody daughter from a hen of the same age. These daughters are being retained for a further performance record.

The Effectiveness of Selective Breeding to Reduce Mortality in Rhode Island Reds. (Regional Poultry Research Laboratory and Departments of Veterinary Science and Poultry Husbandry, Massachusetts Agricultural Experiment Station, cooperating.) Results of breeding high and low mortality lines through three generations were completed in November 1946. The two lines differed significantly in mortality rates to eight weeks, from eight weeks to six months, and from six to eighteen months in both sexes. The low mortality line exhibited a higher mortality rate than the control line during the same period. Complete data are ready for publication.

Genetic Laws Governing the Inheritance of High Fecundity in the Domestic Fowl. (F. A. Hays and Ruby Sanborn.) A number of phases of the problem of breeding for high fecundity have been studied. The value of egg records as a criterion for selecting breeding females was reported in *Poultry Science* for November 1946. The accuracy of limited trapnesting has been investigated and results reported in Station Bulletin 438. Further consideration has been given the problem of intensity, particularly from the inheritance standpoint, and the report is being published as a Station bulletin. The data point to the importance of heredity in developing high intensity. There is no evidence of sex-linked genes being

concerned. A special study is being made of the value of progeny testing in breeding for high fecundity, and of the possible effect of air temperature on egg size in Rhode Island Reds.

Early sexual maturity, very low broodiness, and high persistency are well fixed in the flock, but intensity and incidence of winter pause remain variable. Efforts are being made to reduce variability in egg production by a search for inherited factors operating.

A Study of Fertility Cycle in Males. (F. A. Hays.) Synthetic thyroxin was used in the spring of 1947 to activate males of various ages to higher fertility. Artificial light was also tested. Results showed that the hormone was not quite so effective as artificial light. Cockerels have not been affected by any agents used.

The complete report of this and previous years' tests is now in press.

Genetic Analysis of Rhode Island Red Color Inheritance. (F. A. Hays.) This project was completed in the fall of 1946. Colorimetric analysis of intensity of soluble feather pigment suggests that less intense pigmentation depends on several dominant genes. A complete report is ready for publication.

Secondary and Adult Sex Ratio in Relation to Hatchability. (F. A. Hays.) High and low hatchability lines have been developed through the third generation, but have not yet been carried long enough to be definitely established. A search for lethals responsible for low hatchability and abnormal sex ratios has not been very fruitful as yet. Preliminary evidence indicates, however, that sex differences in embryonic mortality rates play considerable part when secondary sex ratios are abnormal.

Breeding for High and Low Incidence of Internal Defects in Hen's Eggs. (F. P. Jeffrey and C. E. Walker.) Strains of Rhode Island Reds have been bred which differ significantly in incidence of meat spots in their eggs. Continued selection will be practiced to further differentiate these strains. There is a small but significant association between incidence of meat spots and degree of shell color, the eggs with darkest shell color tending to carry more meat spots than those with the lightest shell color. Egg shell color varies widely in these strains.

Breeding White Plymouth Rocks for Eggs and Meat. (F. P. Jeffrey.) A strain of White Plymouth Rocks has been developed which is pure for the Columbian pattern; that is, males of this strain when mated with Rhode Island Red or New Hampshire females give red pullets and "Columbian" males.

Hatchability Factors in Products of Vegetable Origin-Distillers' Dried Solubles as Supplements to Soybean Meal Rations. (Marie S. Gutowska.) Two types of basal rations were used in making up the eight experimental rations. Type I consisted largely of corn and soybean meal supplemented with methionine and choline and small amounts of alfalfa meal. Type II contained less soybean and corn meal but included also wheat bran and oats. Mineral and vitamin supplements were added to both types on an equal basis. Soludri regular and Soludri 3N (Distillers' Dried Solubles), both fermentation products of vegetable origin, were the materials tested for their value as supplements.

The results demonstrated clearly that, whereas the basal Type I ration maintained hatchability at a low level of 49 percent of fertile eggs, the hatchability was improved considerably (36 percent) when a supplement of 3N Soludri was

added. However, hatchability increased only 26 percent when Soludri regular was added, either with or without fish meal. It seems, therefore, that the necessary hatchability factor(s) could be provided by the addition of distillers' fermentation products to a ration of Type I, and that in some cases fish meal does not contribute additional hatchability factors.

The value of the supp'ements was less pronounced in raising hatchability on rations of Type II. The basal ration maintained hatchability at 63.5 percent level. The addition of Soludri increased the hatchability 16.5 percent; but, in order to obtain a good hatchability (87 percent), it was necessary to add 2.5 percent of fish meal in addition to 5 percent Soludri. In this case, the unknown hatchability factor(s) could not be produced without adding a protein of animal origin.

This study suggests the need for further attempts to work out a basal formula for high hatchability laying rations deriving their protein from vegetable sources only. Apparently soybean meal rations of Type I can be used successfully when supplemented with Soludri, especially Soludri 3N, possibly because this supplement may create favorable conditions for microorganisms and synthesis.

SEED CONTROL

Frederick A. McLaughlin in Charge

The Massachusetts Agricultural, Vegetable and Flower Seed Law was amended in 1946 and became effective on August 24 of that year. More comprehensive requirements of the amended act, together with a growing appreciation by the public of the merits of tested seed, resulted in a greatly increased number of samples received by the laboratory over any previous year. From July 1, 1946, to June 30, 1947, 5,853 samples were received and worked in the seed laboratory; an increase of 679 samples over the previous year. The laboratory also received and cleaned 100 lots of tobacco seed.

Enforcement of the Seed Law, together with an increased interest in good seed on the part of seedsmen and the public, has resulted in more correctly labeled and better quality seed being offered for sale. In 1947 only 1.94 percent of the vegetable seeds sampled by a State inspector and tested at the seed laboratory were found to be below standard. There has been a marked increase in the number of samples above standard each year since 1936 when 28.36 percent were found below.

Operation of the Seed Law is reported in an annual bulletin issued for that purpose.

DEPARTMENT OF VETERINARY SCIENCE

J. B. Lentz in Charge

Poultry Disease Control Service. (H. Van Roekel, K. L. Bullis, G. H. Snoeyenbos, O. S. Flint, F. G. Sperling, M. K. Clarke, O. M. Olesiuk, and E. M. Allen.

1. *Pullorum Disease Eradication.* During the year 1946-47, a total of 1,271,378 blood samples was tested—1,238,983 from chickens, 19,796 from turkeys and 12,599 from other fowl. A total of 651 chicken and turkey flocks was tested The percentages of positive tests were 0.13 for chickens, 0.51 for turkeys, and 0 for other fowl tested. There was a slight increase over the previous season in the number of flocks and samples tested.

It is encouraging to note that the pullorum disease status of Massachusetts poultry flocks has steadily improved during the past six years, even though both the poultrymen and the laboratory have been faced with many difficulties. Massachusetts can feel proud of the fact that 95 percent of the chickens tested are in 100 percent non-reacting flocks.

2. *Diagnostic Service.* During the calendar year of 1946, 4763 specimens were received in 858 consignments, of which 448 were delivered in person. The specimens were classified as follows: 4028 chickens, 642 turkeys, 18 pheasants, 17 rabbits, 11 each of bovine semen and canine feces, 10 each of ducks and pigeons, 7 quail, 3 trout, 2 bovine organs, and 1 each of bovine blood, bovine fetus, canary, and swine.

Coccidiosis (105), tumors (64), pullorum disease (58), fowl paralysis (37), and Newcastle disease (47) were the disturbances identified most frequently. A definite diagnosis was not reached in 46 outbreaks of respiratory disease. Avian tuberculosis was not identified during the year. Fowl cholera was identified in 19 instances, including 10 new premises. Fowl typhoid was recognized 19 times, and 17 were on premises where the disease was not known to have existed previously. There were fewer cases of cholera and more of typhoid than in the previous year.

Cockleburs caused severe injury in one group of chicks three weeks of age. Peanut shell litter containing cockleburs had been added to the litter already on the floor, and the chicks began eating the burs almost immediately. As many as five were found in some of the chicks examined. The cockleburs caused severe mechanical injury and inflammation at the site of lodgment, usually the lower esophagus.

The 642 turkeys were received in 140 consignments. More than half of the examinations were on birds less than four weeks old. Coccidiosis, paratyphoid infection, pullorum disease, and swine erysipelas were the conditions encountered most frequently.

The number of cases of *E. rhusiopathiae* infection (swine erysipelas) in turkeys called to the attention of the laboratory equalled that of the previous ten years combined. In previous years the outbreaks had occurred principally on porches in September and October or on range in November and December. In 1946 one outbreak occurred in February in housed breeders, and several were on range during the summer and early fall. The latter outbreak continued for some time and one owner reported losses of approximately 12 percent.

3. *Flock Mortality Studies.* Necropsies were made on 225 birds from the Experiment Station flock, including 141 females, 76 males, and 8 unidentified of the group hatched in the spring of 1945. No new observations of significance were made on examinations of these birds.

4. *Infectious Bronchitis Control.* During 1946, 217 flocks were enrolled in the infectious bronchitis control program. The results continue to be satisfactory, and the flock owners regard this control program as a valuable service to the industry. During the year birds from 101 flocks were tested for their immunity to infectious bronchitis, 64 of which were found to be immune, 35 susceptible, and 2 questionable.

Furthermore, 114 flocks were tested for Newcastle disease with the serum-virus neutralization and hemagglutination-inhibition tests; and 47 were found positive, 64 negative, and 3 questionable. When indicated, attempts were made to isolate

the virus from tissues of infected birds. The disease was identified in Berkshire Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Plymouth, Suffolk, and Worcester counties. Whenever possible, complete case histories on natural outbreaks are being collected, and that information should be helpful in investigating and controlling this disease.

In 8 flocks, eggs collected during active outbreaks of Newcastle disease were examined for the presence of virus. Among 256 eggs examined, the virus was recovered from 34 eggs received from 4 flocks.

Preliminary studies reveal that birds recovering from exposure to the Newcastle virus will give a positive test with the hemagglutination-inhibition test (H I) in a shorter time than with the serum-virus neutralization test. Hemagglutination inhibiting bodies have been found in sera of birds as early as five days after artificial infection. The H I test should prove of great value in the early diagnosis and control of the disease.

A few flocks (approximately 10,000 birds) were vaccinated with a commercially produced, killed vaccine. The vaccine failed to induce a definite immunity.

A limited number of experiments was conducted to determine whether eggs selected during the active and terminal stages of an outbreak of Newcastle disease would produce infected chicks on hatching or during the first two weeks of the brooding stage. The trials conducted thus far have yielded negative results. This phase of the disease is being investigated further since the virus has been detected in fresh eggs, and field observations have led to the recovery of the virus from two-day-old chicks.

5. *Mastitis Testing Laboratory.* At the end of the calendar year 1946, facilities for operation of the laboratory were incomplete. Plans were made to set up and test equipment early in 1947.

WALTHAM FIELD STATION

Waltham, Massachusetts

Ray M. Koon, In Charge

The members of the research staff of the Waltham Field Station are assigned to this branch by the Departments of Botany, Entomology, Floriculture, Horticulture, and Vegetable Gardening. Refer to reports of these Departments for results of investigations conducted at this Station.

PUBLICATIONS

Bulletins

436 Annual Report for the Fiscal Year Ending June 30, 1947. 70 pp. September 1946.

The main purpose of this report is to provide an opportunity for presenting in published form, recent results from experimentation in fields or on projects where progress has not been such as to justify the general and definite conclusions necessary to meet the requirements of bulletin or journal.

437 Home Freezing in Massachusetts. By William B. Esselen, Jr., Katherine M. Lawler, and Carl R. Fellers. 27 pp. illus. October 1946.

Home freezing of foods is arousing much interest. In Massachusetts freezing seems best suited as a supplement to other methods of home food preservation. Questions frequently asked by prospective home freezer owners are answered.

438 The Value of Limited Trapnesting to Poultry Breeding. By F. A. Hays. 24 pp. September 1946.

Limited trapnesting reduces labor costs and affords a method by which breeders may secure records on larger numbers of birds. Data reported in this study indicate that safe estimates of complete performance may be made from certain short-time records.

439 Clearing and Improvement of Farm Land in Massachusetts. By Charles R. Creek, Joseph F. Hauck, and Virgil L. Hurlburt. 31 pp. illus. July 1947.

The primary purposes of this study have been to appraise the methods used in farm land improvements, to examine the results in terms of cost-benefit comparisons, and to study the significance of land reclamation for the future of agriculture in Massachusetts.

Control Bulletins

128 Twenty-sixth Annual Report of Pullorum Disease Eradication in Massachusetts. By the Poultry Disease Control Laboratory. 15 pp. June 1946.

129 Inspection of Commercial Feedstuffs. By Feed Control Service Staff. 28 pp. July 1946.

130 Inspection of Commercial Fertilizers and Agricultural Lime Products. By Fertilizer Control Service Staff. 27 pp. July 1946.

131 Seed Inspection. By F. A. McLaughlin. 33 pp. December 1946.

Meteorological Bulletins

691-702, inclusive. Monthly reports giving daily weather records, together with monthly and annual summaries. By C. I. Gunness, M. J. Markuson, and F. J. Sievers. 4 pp. each.

Reports of Investigations in Journals

NUMBERED CONTRIBUTIONS

525 Effect of institutional cooking methods on vitamin content of foods. II. Ascorbic acid content of potatoes. By Anne W. Wertz and C. Edith Weir. Food Res. 11 (4):319-326. 1946.

567 Composition of squashes after winter storage. By Arthur D. Holmes and Albert F. Spelman. Food Res. 11 (4):345-350. 1946.

571 Influence of purified lignin on nitrification in soil. By James E. Fuller. Science 104 (2701):313-315. 1946.

577 The vitamin content of canned and cooked fresh mushrooms. By Angela M. Filios and William B. Esselen, Jr. Jour. Amer. Dietet. Assoc. 22 (9): 772-777. 1946.

578 Nutritional status of women students. By Marie S. Gutowska and Evelyn B. Ellms. Jour. Amer. Dietet. Assoc. 22 (9):763-765. 1946.

579 Enhancing the riboflavin content of mare's milk. By Arthur D. Holmes. New England Jour. Med. 235:360-362. 1946.

580 Carbohydrates in cultivated mushrooms (Agaricus campestris). By John E. W. McConnell and W. B. Esselen, Jr. Food Res. 12 (2):118-121. 1947.

583 The use of oil sprays as selective herbicides for carrots and parsnips. II. By William H. Lachman. Amer. Soc. Hort. Sci. Proc. 47:423-433. 1946.

585 Sodium selenate for red spider control in Massachusetts. By Harold E. White and Warren D. Whitcomb. Amer. Soc. Hort. Sci. Proc. 47:503-506. 1946.

586 Fermate and its effect on rooting of geranium cuttings. By Harold E. White. Amer. Soc. Hort. Sci. Proc. 47:522-524. 1946.

588 Evaluation of tests for rancidity in edible packaged oils. By John E. W. McConnell and W. B. Esselen, Jr. Oil and Soap 23 (12):369-374. 1946.

589 Effect of storage conditions and antioxidants on the keeping quality of packaged oils. By John E. W. McConnell and William B. Esselen, Jr. Jour. Amer. Oil Chem. Soc. 24 (1):6-13. 1947.

590 Stability of vitamins in stored ice cream. By Arthur D. Holmes, John W. Kuzmeski, and Frank T. Canavan. Jour. Amer. Dietet. Assoc. 22 (8): 670-672. 1946.

592 Fermate for the control of mummy berry of the cultivated blueberry. By J. S. Bailey and Thomas Sproston. Amer. Soc. Hort. Sci. Proc. 47:209-212. 1946.

593 The decomposition of certain plant tissues with and without added lignin. By Emmett Bennett. Amer. Soc. Hort. Sci. Proc. 47:252-254. 1946.

595 The influence of Malling clonal rootstocks on the growth of certain apple varieties. By J. K. Shaw. Amer. Soc. Hort. Sci. Proc. 48:171-179. 1946.

596 The anchorage of clonal stock apple trees. By J. K. Shaw. Amer. Soc. Hort. Sci. Proc. 48:166-170. 1946.

597 Bactericidal properties of some surface-active agents. By W. S. Mueller, Emmett Bennett and James E. Fuller. Jour. Dairy Sci. 29 (11):751-760. 1946.

598 Effect of storage temperature on processed and dehydrated foods. By John E. W. McConnell, C. R. Fellers, and W. B. Esselen, Jr. The Glass Packer, 25:714, 716-717, 800, 824-826, 828. 1946.

599 Egg records as a criterion for selecting breeding hens. By F. A. Hays. Poultry Sci. 25 (6):622-627. 1946.

601 Some observations on "quality" in hays. By J. G. Archibald, E. Bennett, and J. W. Kuzmeski. Jour. Dairy Sci. 29 (11):795-800. 1946.

604 Vitamin C content of hens' vital organs after long continued ascorbic acid injections. By G. Howard Satterfield, Thomas A. Bell, F. W. Cook, and Arthur D. Holmes. Poultry Sci. 26 (2):163-166. 1947.

605 The fortification of fruit juices with ascorbic acid. By William B. Esselen, Jr., John J. Powers, and Carl R. Fellers. Fruit Prod. Jour. and Amer. Food Mfr. 26 (1):11-14, 29. 1946.

606 The protection of lilies against damping off. By William L. Doran. Natl. Hort. Mag. 25:4 :385-386. October 1946.

607 Firmness in frozen sliced apples. By William B. Esselen, Jr., W. J. Hart, Jr., and C. R. Fellers. Quick Frozen Foods 9 (5):66 (11), 1946.

608 Preparation of holocellulose from nonwoody plant material. By Emmett Bennett. Analytical Chem. 19:215. 1947.

609 Relationship of seed plant development to the need of magnesium. By Walter S. Eisenmenger and Karol J. Kucinski. Soil Sci. 63(1):13-17. 1947.

610 Food value of hormone-treated tomatoes. By Arthur D. Holmes, Albert F. Spelman, John W. Kuzmeski, and William H. Lachman. Jour. Amer. Dietet. Assoc. 23 (3):218-222. 1947.

616 Cobalt in cows' milk. By J. G. Archibald. Jour. Dairy Sci. 30 (5):293-297. 1947.

619 Composition of mares' milk as compared with that of other species. By Arthur D. Holmes, Albert F. Spelman, C. Tyson Smith, and John W. Kuzmeski. Jour. Dairy Sci. 30 (6):385-395. 1947.

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The feed dealer—An agricultural missionary. By J. G. Archibald. Amer. Feed and Grain Dealer 30 (10):14-15 et seq. September 1946.

Some lessons to be learned from the feed shortage. By J. G. Archibald. New Eng. Farm Finance News 1 (10):4. October 1946.

Now we're learning what it takes to feed a cow. By J. G. Archibald. Eastern States Cooperator 22 (11):11-14. November 1946.

Roughage as a factor in winter feeding. By J. G. Archibald. Canad. Jersey Breeder 2 (1):14 et seq. December 1946.

This feed shortage. By J. G. Archibald and F. H. Branch. Mass. State Coll. Ext. Serv. Spec. Cir. 141. July 1946.

Control of damping-off by a delay in first watering after seeding. By William L. Doran. Phytopath. 36:8:679. August 1946.

Fungicides applied in fertilizer for the control of cabbage clubroot and damping-off. By William L. Doran. Ann. Meeting Northeast. Div. Amer. Phytopath. Soc., November 26, 1946. (Abstract will appear in Phytopathology.)

Present status of the Dutch elm disease in New England. By Malcolm A. McKenzie. Report for 22d Conference convened by New England Council. November 22, 1946.

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